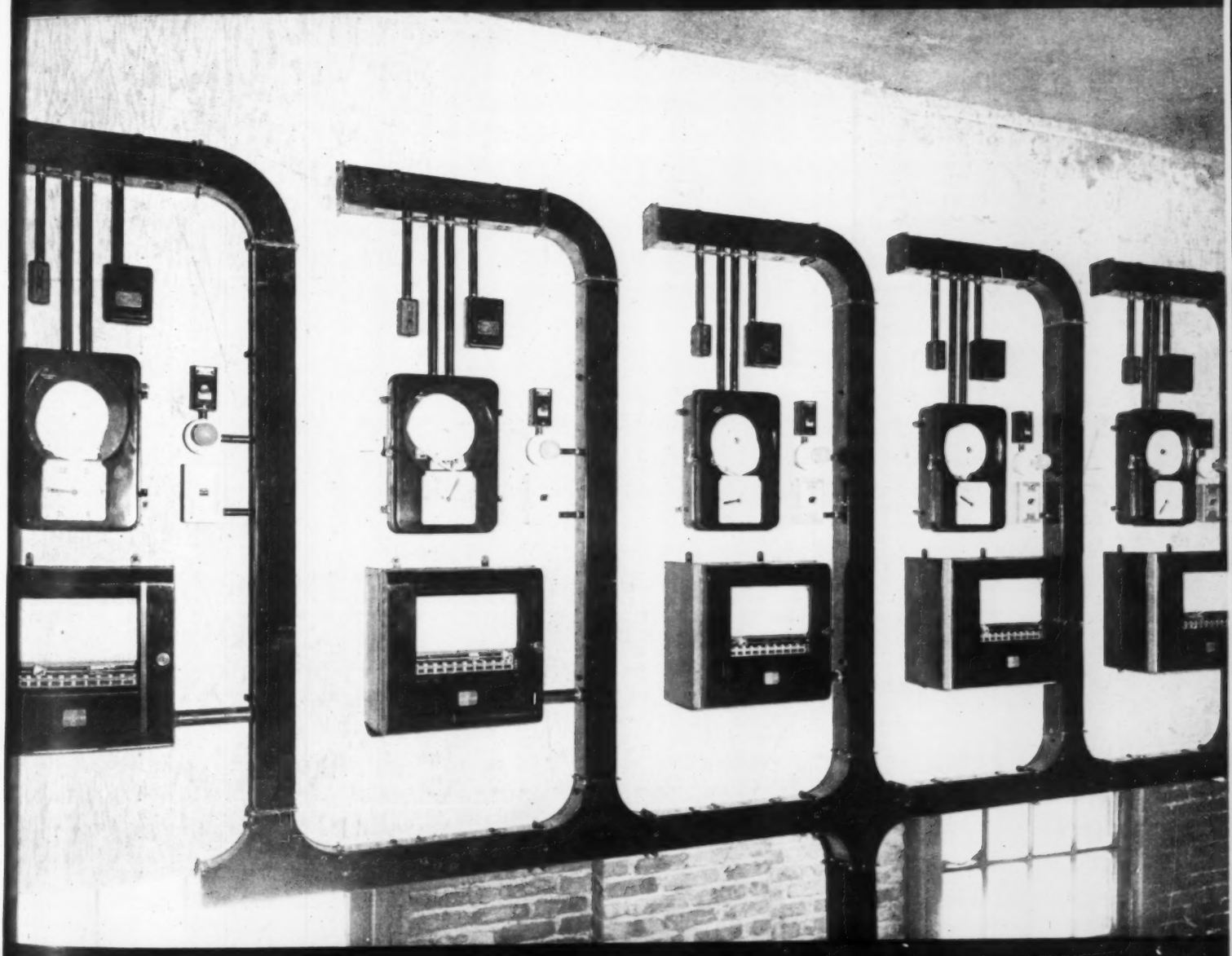
Instruments

THE MAGAZINE OF

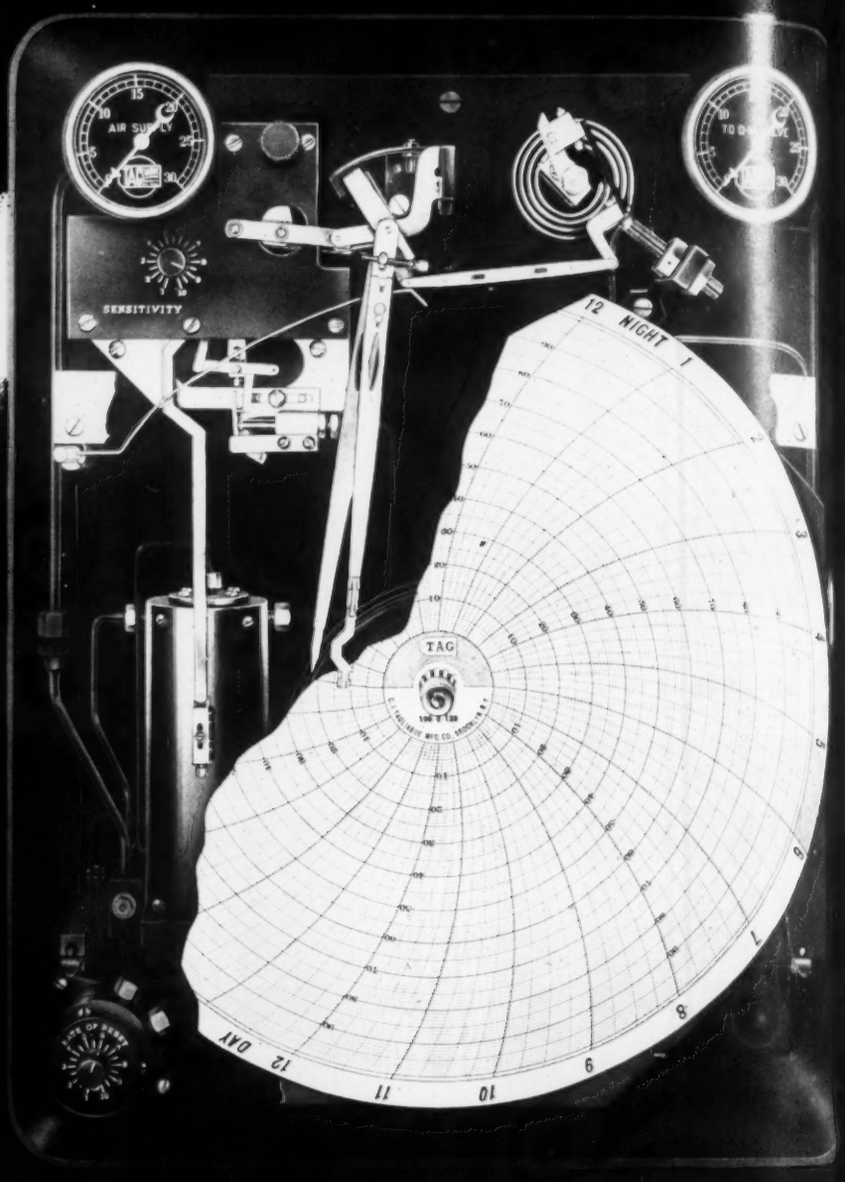
Measurement and Control

Vol. 15
DEC. 1942
No. 12



INCLUDING *Aviation Instruments*

FEELING YOUR PROCESS PULSE CONSTANTLY.... AND CORRECTING OPERATION UPSETS



TAG

RECORDER-CONTROLLER WITH AUTOMATIC RESET

Here's the solution to the problem of overcoming lag in recovery time when upsets strike your process. TAG's RECORDER-CONTROLLER with AUTOMATIC RESET makes swift reaction to process disturbances . . . providing automatic correction of those tardy recoveries that waste precious time and imperil output. This modern Instrument literally "feels" the pulse of your process constantly and initiates automatic valve action in precise degree to halt operation upsets as soon as they start.

Thousands of TAG Recording and Controlling Instruments are in effective service today in the synthetic rubber, chemical, catalytic cracking, aeroplane engine testing, ordnance and food fields. At this time, when uninterrupted production is vital and needless re-runs set back the war effort, you particularly need the well demonstrated control efficiency that TAG offers.

C. J. TAGLIABUE MFG. CO.

Park & Nostrand Ave's., Brooklyn, N. Y.

TAG

Instruments THE MAGAZINE OF Measurement and Control

M. F. BEHAR, Editor

Long Wars Create Short Tempers

TODAY is December 7th, first anniversary of "a day that will live in infamy" as our Commander-in-chief prophetically declared. The last few days, editors and commentators (and even some newspaper and magazine ads) have been remembering Pearl Harbor so rhetorically that I tore up the "masterpiece" I had been polishing up for this page. . . . You're welcome!

There are several things which all of us can do, not merely as citizens of our beloved country but *as instrument men*. Some of these things are obvious (for example, extending the use of automatic instruments to speed up war production); other things are not so obvious. Here is one:

As the burdens of war begin to hurt, many of us tend to become somewhat irritable. Therefore I ask you to read (and *heed*) a portion of the first editorial I wrote on being appointed editor in June 1933:

> . . . To be sure, the millenium has not arrived. . . . Sales engineers . . . still number in their midst a few "promise-anything-to-get-the-order" sinners. Manufacturers still print a few exaggerations. And some users still display cynicism and intolerance toward the most ethical of those who try to serve them . . . Get together! Ask and answer all relevant questions! . . . Above all, don't nurse grudges. If you think you have a grievance, get it off your chest. . . .
>
> **We are all colleagues in one esteemed profession: All men who invent, design, build, sell, specify, apply, install, service and maintain measuring instruments, gages, meters and automatic control equipment belong to one fraternity. . .**

Some "pet peeves" will only vanish when brought out into the light. Therefore suppliers and users are hereby invited to present their "cases" in the columns of *Instruments*. This invitation applies not only to mutual or reciprocal grievances; it applies to kicks against third parties outside the field of instrumentation; it applies to protests against circumstances. I am convinced that these difficulties were not deliberately created by men but arose from *new situations*—new relations, new ways of transacting business and installing products.

Anyway, get it off your chest! Write it up carefully, just as a lawyer presents his "case." Beginning in our February issue, and for the duration, this type of article (hitherto rejected) will be accepted. I believe this new policy will do much to end "pet peeves." As I wrote on this page one year ago, just after Pearl Harbor, "Every good American is a Boy Scout at heart . . . Of all good Americans none is better than the measurement-minded, the one with a keen sense of true values—*you*!"

—MFB

The Counter Reads **00180**

and thereby registers the end of the fifteenth year of *Instruments'* service to users of measurement and control devices—service to the

UNITED STATES OF AMERICA

The entire staff of *Instruments* wishes you

A Merry Christmas and a Happy New Year

On Joining the Armed Forces

IN answer to requests from subscribers for information on opportunities for doing instrument work in the Army and Navy, last month's editorial was devoted to that subject and to the needs of industry. Its title was "General Man-power Needs; Individual Decisions." It summarized a number of points and quoted Army and Navy releases. It ran to more than two pages—the longest we ever printed. Now, as this issue goes to press, news comes of

(1) An Executive Order giving the War Man-power Commission "sweeping power over the country's man-power, including control over the operations of the Selective Service system and the moving of workers in non-war industries into war industries."

(2) Suspension of induction of "all" men 38 or older.

(3) Stoppage of "all" voluntary enlistments of men between 18 and 38.

(4) Training of workers for vital war industries placed under War Man-power Commission.

(5) Enlargement of powers of United States Employment Service.

These are the high lights. By the time you receive this copy of *Instruments*, the broad Executive Order will have begun to be translated into numerous specific Army and Navy orders and statements, civilian-agency regulations and statements, etc. We feel safe in predicting that *there will be exceptions*—particularly affecting highly-skilled men, professional engineers, physicists and chemists, experienced production men, experienced teachers, industrial executives and various other classes of *Instruments* subscribers. Watch the newspapers carefully during the next month or so and bear in mind that the American government is the best on earth, so that if you have been considering making a change for the *mutual benefit* of the War Effort and of yourself, your government will not "freeze" you but will help you. For example we have just 'phoned to a local Army office and have been assured that "skilled men not otherwise available" are still wanted even if they are over 38, although, of course, the Army will strive to obtain such men from "other than essential war industries or occupations." The point is that America is American and Americans are America. When you read the papers, disregard the sour-puss commentators who will try to find fault.

Put Idle Instruments to Work

UNDER this heading we published in recent issues the plans of the Instruments Publishing Company and of others. If you have idle instruments, or if you cannot obtain the instruments you want, look up page 396 of the October issue and write to the Available Instruments Department as directed. In this connection, Mr. Rimbach, who has charge of that Department, has asked us to thank on this page the many "haves" and "wants" who have taken advantage of the IPC plan: a large percentage of "haves" and "wants" got together. That's the American spirit!

The Pitfalls of Temperature Measurement*

By C. O. FAIRCHILD

Director of Research, C. J. Tagliabue Mfg. Co., Brooklyn, N. Y.

Introduction

THE very nature of temperature, which is a unique physical concept, is such that it is difficult to clearly define and measure. Our initial more or less vague ideas about temperature spring from our sensations of heat and cold. If we touch an object which feels warm this sensation resulted from the flow of heat to our finger. We haven't time to discuss the physiology of this sensation but must direct our attention to the fact that temperatures are not sensed by any other means than by an observation of a flow of heat. Maxwell defined the temperature of a body as its thermal state considered with reference to its ability to communicate heat to other bodies. It follows then, that in order to measure the temperature of a body we must determine its ability to communicate heat to another body. This means that we must control and observe heat transfer, and we are in immediate difficulty, because heat has a disconcerting characteristic of flowing through everything, and at rates which vary over wide limits. For example, if we touch a piece of metal at 120°F., heat flows very rapidly to our finger and we conclude the metal is very hot. On the other hand if our fingers are only a little protected by callous we can pick up and hold glass at 200°F. because of the poorer conductivity of the material. We can expect, then, to find pitfalls in the practical matter of handling heat flow—one source of trouble.

In order to specify temperatures, numbers have been arbitrarily assigned to critical thermal states such as melting and boiling points of various substances; for example 0°C. for the melting point of ice and 100°C. for the boiling point of water. The variation of numerous physical properties of substances have been experimentally observed so that they can be used for measuring temperatures between these critical points. Hence we must become familiar with the thermometric properties of various substances—a second source of trouble.

If we peruse the first 23 pages of the A.I.P. Temperature Symposium,† where Wensel fully describes our concept of temperature** and how it is measured, we learn that the physical laws with which we must become familiar in order to understand what we are doing when we attempt to measure temperature, are complex and difficult to handle. They are a third source of pitfalls.

Briefly, we conclude that our success in avoiding pitfalls will be commensurate with our knowledge and experience, and their painstaking and attentive application to problems in hand. When we observe or measure a temperature we note the coincidence of some pointer on a scale. We must think beyond this simple observation, and not be satisfied as we are when we lay a rule between two points, or adjust weights on a balance, and then watch for the required coincidence. Suppose that we are about to use a clinical thermometer. We must be sure that the patient has not had a drink during the previous half hour. We must shake down the mercury in the capillary column. Next we place the thermometer bulb carefully under the tongue where it will be nearest circulating blood. Then we wait—for thermal equilibrium to be established. Having assured ourselves that the thermometer was colder than the patient's mouth before we inserted it, we can now remove it, because it is designed to register a maximum, before we note the coincidence. We will have measured a temperature successfully, provided that we have had the faithful coöperation of the patient. One medical authority states that there are seven or eight ways for the patient to deceive the doctor who is taking his temperature. We will not dwell on these, but emphasize the point that the mere observation of the coincidence on a scale is likely to be all too disarming, and lead one to thoughtlessly act as though he had measured a temperature.

Conditions to be Met

The things whose temperature we have to measure from time to time are so varied in form and condition that we can only touch upon the principal sources of difficulty. One is temperature gradient or lack of uniformity of temperature. At ordinary temperatures this imposes the added difficulty of obtaining sufficient immersion of a thermometer or thermocouple. The well-known test for sufficient immersion (provided that there is a space at *uniform* temperature) is to observe that the immersion selected is enough that a little less gives the same reading. This test fails completely in the presence of gradients and we find it necessary to use our wits to the utmost on this apparently simple problem. We may find that an awkward series of experiments are necessary to provide even an approximate answer. We should preferably turn our attention to noting the direction of flow of heat and the possibility that the thermometer can be inserted at right angles to this direction, that is, in a nearly isothermal layer. This will tend to overcome the unavoidable circumstance that, as in most cases, heat is flowing along the thermometer, and if the temperature is above that of the surroundings, this heat is to be supplied from the oven or bath or whatever we are measuring. This kind of so-called lag in a thermometer is very often a difficult characteristic to combat. Every means should be used to promote thermal contact and low resistance to heat-flow between the thermometer and the object. If the object is a solid, we are principally concerned with whether or not it is a good conductor of heat. If it is a liquid, we must see that it is flowing past the thermometer with sufficient velocity. For example, the thermometer should not be immersed in any region where the liquid is stagnant.

Before touching on the subject of temperatures of gases we shall mention the other important condition, that of inconstancy or variation of temperature with time. Here we are concerned also with the promptness of response of the thermometer, that is, its time lag. Experience in the art is especially important in finding the right answer to the problems which arise from these circumstances. It is necessary that the observer use plenty of time in his observations (e.g. 1 hr. if a hunting period is 15 min.) before drawing conclusions regarding the effects on the accuracy of measurement, particularly where large masses may be varying slowly in temperature.

As higher and higher temperatures are met, radiation becomes more important in comparison with convection. If the temperatures are high enough to be measured with a radiation or optical pyrometer then we are principally concerned with the lack of blackbody conditions consistent with the presence of gradients. With these pyrometers true temperatures are indicated only where blackbody conditions are found. If the temperature within an enclosure is not uniform, then when the pyrometer is sighted at the hottest zone the temperature indicated is below the true temperature and when sighted at colder spots the temperature indicated is higher than the true temperature. Sometimes it is possible to avoid this difficulty with the optical pyrometer by sighting it at a small hole in the inner wall of a furnace. The large source required for radiation pyrometers does not permit this. In case temperatures are varying they can be followed rather rapidly with either of these pyrometers and if careful attention is paid to the times at which readings are made, then proper conclusions may be drawn. We have not in mind the radiation pyrometer which is sighted into a closed tube built onto it: this instrument has more

*Presented before the New York Society for Measurement and Control October 27, 1942.

†Published by Reinhold Publ. Corp., N. Y., 1941; reviewed in *Instruments*, Feb. 1941.

**See also Worthing's paper on the temperature concept in the same book, page 41.

...ly the characteristics of a thermocouple so far as dis... ion at this point is concerned. In the use of the open ...iation pyrometer we must look out for the presence of s...ke or of carbon dioxide and water vapor. These gases a... relatively opaque to infrared radiation and their pres... results in low readings. It is particularly important to ...member that the interior of a hot furnace does not ap... the same to a radiation pyrometer as it does to the ... If our eye had a similar sensitivity to that of the py...meter, carbon dioxide and water vapor within a furnace w...ld appear as dense clouds.

The measurements of hot gases present extraordinary difficulties if they are confined by walls which are at a different temperature, for example in the case of hot gases in boiler chambers or flues. To solve this problem in the more difficult cases there has been developed the so-called high-velocity thermocouple described by Mullikin in the Temperature Symposium. The solution lies principally in that the gases pass the thermocouple rapidly and that the walls visible to the thermocouple are very nearly as hot as the gases. This last is accomplished by double shielding of the thermocouple. Many arrangements for this problem are described by Mullikin.

Test Methods

Those who are interested in the problems of measuring temperatures find it necessary to learn methods of testing thermometers and pyrometers with some degree of precision and accuracy. We should like to present the point of view that the first requirement in a testing laboratory is up-to-date and adequate information such as values of the fixed points on the temperature scale, tables for thermocouples and resistance thermometers, standard methods of testing, etc.

So far as the technique of methods is concerned the primary requirements are temperature uniformity and constancy of baths and furnaces and always close similarity of the standard instrument and the one to be checked. If they are different, errors of comparison are almost completely unavoidable. These errors of course will be augmented by inadequate stirring of a bath for example, or temperature gradients in a furnace.

Of all the test points available the greatest reliance should be placed on the ice point. Ordinary clean ice broken into small pieces and wet will reproduce this fixed point very accurately. Only a few industrial laboratories are provided with equipment for testing at other fixed points and we should like to warn against the use of boiling points of liquids except for obtaining a constant temperature for comparing two or more thermometers. The steam point for example, is not reproducible without an excellent hypsometer and a very expensive barometer with all the cumbersome tables for correcting the barometric reading for temperature, latitude and altitude. Most laboratories are supplied with standard specially-calibrated instruments for test purposes.

If it is necessary to compare a mercury thermometer with a resistance thermometer the bulbs should be as near each other as possible in a well-stirred bath. If the resistance thermometer requires an immersion of say 10", and the permissible immersion of the thermometer is only 6", then we can expect errors of measurement. If it is necessary to test partial-immersion thermometers it is preferable to have a whole set of standard thermometers of the same kind and dimensions so that the immersions can be identical during the test.

Thermocouples are compared by welding their hot junctions together and if this cannot be done the junctions should be put inside a metal block having a small hole drilled in it. While mercury thermometers and resistance thermometers which are off calibration have to be tagged with corrections, thermocouples can often be restored to their original calibrations or very near them. In the case of base-metal thermocouples of 22 gage and larger, it sometimes suffices to remove the outer oxide. Personal instruction or teaching is required for learning how to restore rare-metal thermocouples.

In testing electrical thermometers special care should be exercised in the connection of copper leads and extension leads and in the polarity of reference junction connections. Laboratory potentiometers *without* automatic reference-junction compensation should be at hand. Depending on the degree of accuracy aimed at, a special Wheatstone bridge for resistance thermometers may be acquired. Precise resistance thermometry requires the use of four-lead thermometers and if only three-lead thermometers are used they should be tested by comparison with standard high grade mercury-in-glass thermometers.

Characteristics of Mercury Thermometers

The so-called emergent stem error is our first stumbling block. We should know first how to correct for this. Be sure that we know what kind of glass and the data applicable to it. There are only two common ones used, one is a lead glass with a small coefficient of expansion for use up to a little over 750°F. and the other is a borosilicate glass with a relatively large coefficient. These corrections are best applied to so-called total-immersion etched-stem thermometers. Etched-stem thermometers marked for use at partial immersion should always be used immersed to the mark and not at some other value to be corrected for.

The mercury-in-glass thermometer properly used can provide very accurate measurements in spite of the fact that glass is not a stable substance. Due to this natural instability high accuracy is obtained only by the use of repeated checks at the ice point. This means of course that a mercury thermometer on which we depend for high accuracy must have the ice-point engraved on it for check purposes. If it is heated to the upper part of its range, and cooled back down to the ice-point, the bulb will remain slightly enlarged for a time depending on how high and for how long a time it was heated. In precise testing, thermometers should be used at progressively higher temperatures and not first high and then at an intermediate point. Further details on these characteristics will be found in the A.S.T.M. Standard "Methods of Testing Thermometers" as described by Mueller and Wilhelm.

The industrial form of mercury-in-glass thermometer in which the bulb and stem are heavily protected by a sheath and case, and possibly constructed to screw into a socket, cannot be expected to provide the accuracy obtainable from a bare thermometer. The mass of metal surrounding it adds a great deal to its lag and to immersion errors. For this reason it is calibrated under conditions approximating those which may prevail during its use. The exposed parts should not be subject to strong drafts nor on the other hand should they be wrapped in extra insulation to protect them from drafts. It is well to repeat that these thermometers should not be installed where the fluid medium is apt to be stagnant, because in many cases a large amount of heat must flow to the bulb to keep it up to temperature.

Pressure-spring Thermometers

All thermometers in this class consist of a metal bulb connected through a small-bore metal tube or capillary to a thin-walled flattened and coiled metal tube, closed at the far end, which unwinds with increasing internal pressure and moves a pointer or pen-arm. If this pressure system is partly filled with a relatively volatile liquid, so that the free surface of the liquid is in the bulb, then the pressure will always correspond to the temperature. There will be no error of capillary and spring temperatures provided that these are constantly above or below the temperature of the bulb. The scale of these so-called vapor-pressure thermometers is very far from uniform. This makes it difficult to apply corrections, and careful attention should be afforded if any attempt is made to alter the mechanism attached to the pressure spring.

If the system is completely filled with a liquid such as mercury, under pressure enough to keep it from vaporizing at the highest temperature showing on the scale, as in the mercury-in-glass thermometer, the result is much the same as with the latter. Unless compensating means are em-

(Continued on Page 542)

METROLOGY
The Science of Measurements

By S. R. WILLIAMS
Professor of Physics, Amherst College

METROLOGY is "the science of, or a system of weights and measures." (Webster's New International Dictionary, 1936.) It is "the science that treats of systems of weights and measures, or of units of measure." (New Standard Dictionary of the English Language, 1938.) A metrologist is one who specializes professionally in the units whereby measurements are made. There are only a handful of professional or full-time metrologists in all the world, but all of us have been part-time metrologists since childhood when we measured how far Tommy could jump, how much Harry could lift, how long Jimmy could stay under water.

In order for one to make quantitative measurements it is necessary to establish units, in terms of which a magnitude* can be measured. To be effective, the unit must be simple and easily and accurately reproducible.

As man progressed in the arts and sciences in his upward climb it became more and more essential that he have some system of weights and measures. Even on a barter system, amounts of materials had to be evaluated in some way. Our systems of weights and measures, like Topsy, have "just growed up."

In the early days the king's foot or his forearm served as the standard unit of length. See Fig. 1. These were the visible, tangible units, back to which all other measurements of length could be referred. Even today the housewife will stretch a piece of cloth from the point of her nose to the end of her extended fingers and declare that she has a yard of the material. Inasmuch as the length of the king's foot or his forearm varied when a new king came to the throne, it soon developed in man's thinking that something more universal should be adopted.

Our modern yard length is the outcome of this thinking. The English yard, divided into three equal parts, is an approximation to three times the length of the average king's pedal extremity, one times the length of his arm. In order to have some standard of length a bar of metal three times

*"That-which-is-measured" must *be* a bigness or smallness . . . a *magnitude*. . . The result of a measurement is a numeral, a mathematical *quantity*. (Behar, "Fundamentals of Instrumentation," pages 28-29.)

Fig. 1. "One Yard" was the length of the King's arm.
[This may be a copyright drawing but neither Dr. Williams nor we know whom to credit, though we should like to.—INSTRUMENTS]

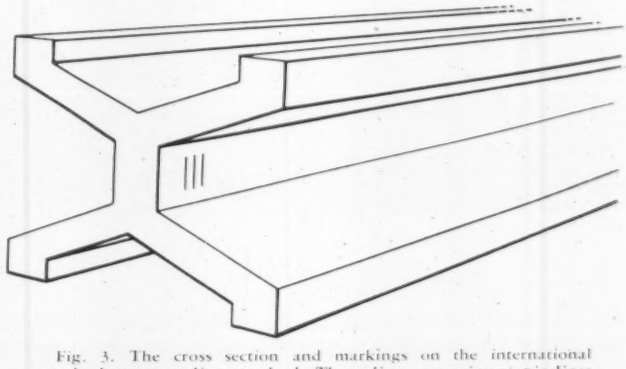


Fig. 3. The cross section and markings on the international standard meter—a line standard. The rulings are microscopic lines in the "trough" of the bar near each end.

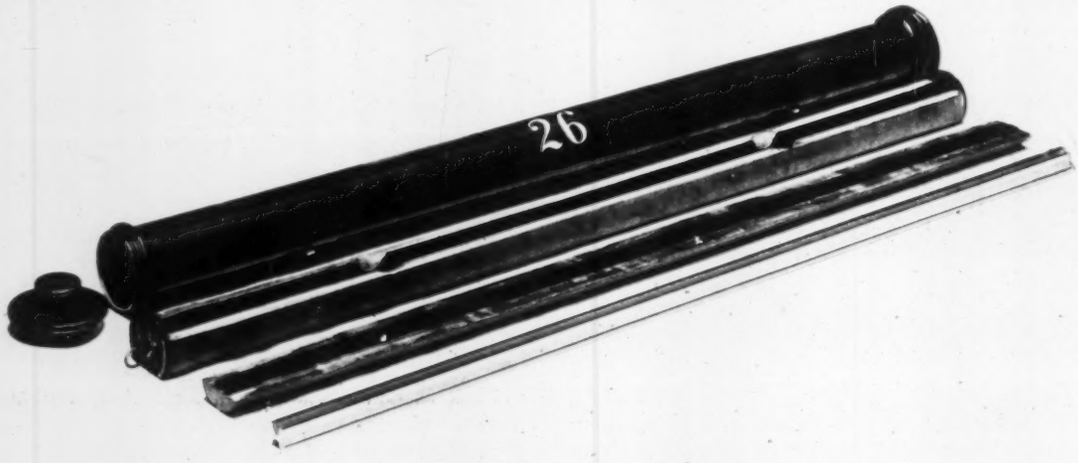


Fig. 2. One of the original thirty bars now kept at the International Bureau of Weights and Measures. The bar is protected by a wooden case, which in turn fits inside a metal cylinder with a screw cap. Meter No. 6 is the authorized International Standard of Length. No photograph of it exists. No. 26 is employed for ordinary comparison work.

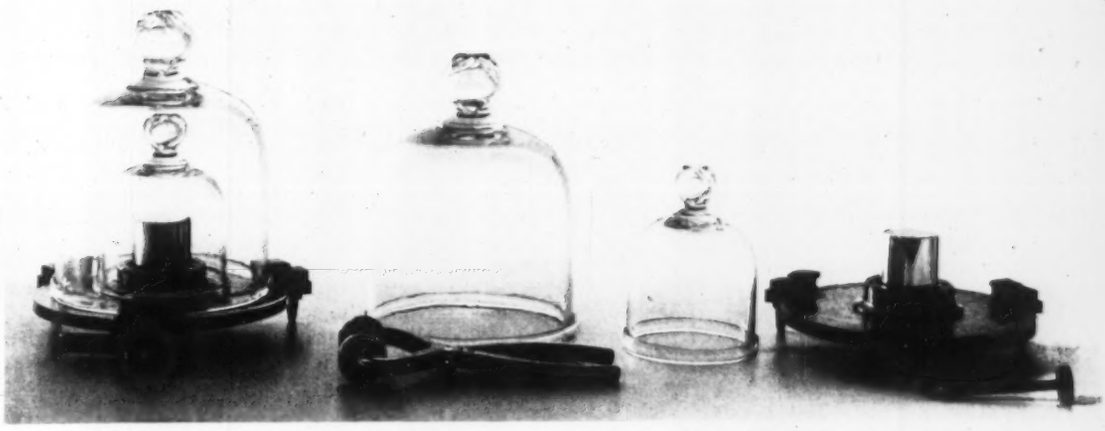


Fig. 4. This photograph shows National Standard Kilograms Nos. 4 and 23. No. 20 on the right, uncovered, is the primary standard of mass for the United States.

that of the foot—which is to say, the yard—was produced and the yard became the standard unit of length in England and is still used in England and America.

In this series of discussions we shall deal only with physical measurements. For such measurements there are three fundamental units in terms of which all physical magnitudes may be expressed. These are the fundamental units of Length (L), Mass (M), and Time (T). There are no units back of these three. These three are fundamental. To represent these fundamental units of physical measurement we must have standard units. They must be physical embodiments of these three fundamental units. In the process of time the civilized countries of the world have officially recognized one system of standard units for making physical measurement which is known as the metric system. It is a decimal system as well, which offers a great deal of convenience in calculations.

It is a fairly long story, that of how our standards were finally made and defined, but it will add to brevity and clarity to say that the three standards for the fundamental units of length, mass and time may be defined as follows:

1. LENGTH—The standard of length is the meter and is defined as that distance between two transverse lines marked on a certain platinum-iridium bar preserved in the International Bureau of Weights and Measures near Paris, France. See Fig. 2. Fig. 3 shows the cross section and markings on one end of the International Standard of Length.

Fig. 5. Kilogram No. 20, the National Standard of mass, a cylinder 39 mm. in diameter and 39 mm. high, with slightly rounded edges, iridium. It was furnished by the International Bureau of Weights and Measures in pursuance of the Metric Treaty of 1875. Early in 1937 it was taken back to Paris for recomparison with the International Standard. The most careful tests showed that the United States Standard had changed by only one part in fifty million during approximately fifty years.

Fig. 6. Interior view of the vault at the National Bureau of Standards in which the standards of length and mass of the United States are kept. Dr. Lyman J. Briggs, Director of the Bureau, is shown holding the National Standard of length, Meter No. 27. The national standard of mass, Kilogram No. 20, is under double bell jars on the center of the second shelf in the case. Both of these standards are made of an alloy of platinum and iridium. They were supplied to this country by the International Bureau of Weights and Measures.

If one takes the distance from the center scratch of the three shown to the middle one of the three on the other end, that distance is defined as the standard meter of length when the bar is at zero degrees Centigrade. Every civilized country in the world has one or more bars made as nearly like this International Standard as it is possible to make it and these prototypes serve as the Standard Unit of Length for that particular country. Originally the meter

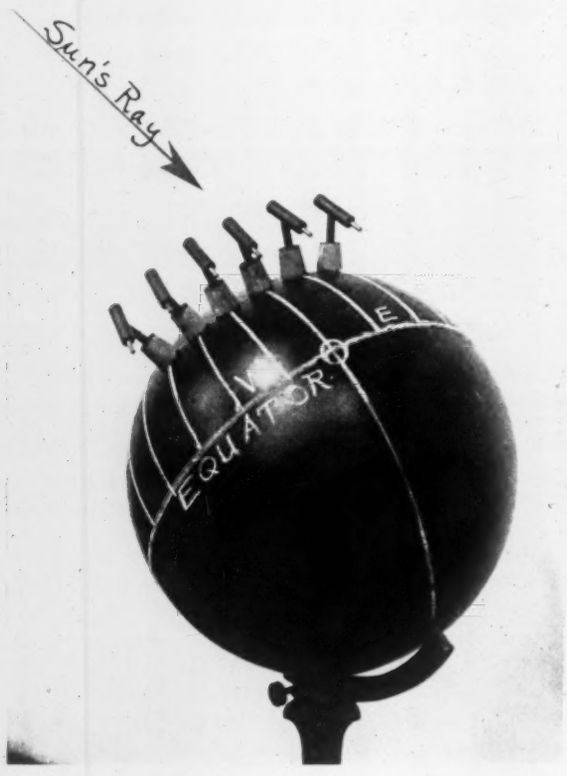


Fig. 7. The globe represents the earth laid off with meridians spaced 15° or 1 hour apart. An observer at each telescope would see the star appear on the cross wire of this instrument one hour later than his neighbor to the East. The prime meridian is designated as the one crossing the Equator at 0.

was supposed to be the one-ten millionth part of the Earth's quadrant, but inasmuch as the Earth's quadrant could never be accurately measured the International Congress of Weights and Measures simply defined the Standard Length as the distance between two certain fiducial lines on a certain platinum-iridium bar when at the temperature of zero degrees Centigrade.

2. MASS—In an analogous fashion the same International Congress of Weights and Measures defined the Unit of Mass as the mass of a certain platinum-iridium cylinder also preserved at the International Bureau of Weights and Measures and which they called the Kilogram. Fig. 4 shows the duplicates owned by the U. S. A. and preserved at the National Bureau of Weights and Measures in Washington, D. C. Fig. 5 is a close-up of the American national standard, while Fig. 6 shows how our American standards are protected at the National Bureau of Standards. Originally the Kilogram was supposed to be the mass of 1000 cubic centimeters of water, but it simplified matters to define the Standard Unit of Mass as the mass of a certain definite platinum-iridium cylinder preserved in the International Bureau of Weights and Measures, near Paris. No photographs have ever been taken of these International standards, so only the Standards for the U. S. A. are shown. The International Standards are inspected from time to time by the International Committee on Weights and Measures when they meet. The standards are kept in subterranean vaults under three (3) different locks and keys. One key is held by the Director of the International Bureau of Weights and Measures, one key is in the hands of the Director of the Archives of France, and the third is held by the President of the International Committee on Weights and Measures. The standards cannot be inspected unless these three keys are present at the same time. The importance of these standards is shown by the care with which they are preserved.

3. TIME—The Standard Unit of time is the second. It is defined as the 1/86400 part of a mean solar day. Due to the motion of the Earth in its orbit about the sun the length of the solar day varies. Roughly it is the time it takes the Earth to rotate upon its axis. If one measures the time from when the sun is directly over our meridian until it is directly over it the next time, that will be called a solar day. If one takes the average of all the solar days in the year, that will give the average length of a solar day and 1/86400 of this period is the second.

Fig. 7 shows how one may think of a light ray coming from the sun and entering an observing telescope set up at some fixed point on the earth's surface, say on the prime meridian as shown in Fig. 8. As the earth rotates from

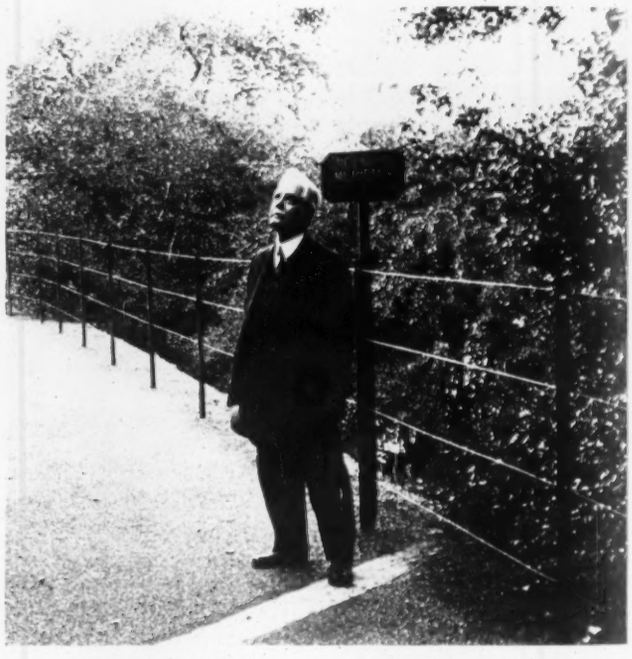


Fig. 8. The late Professor Dayton C. Miller, standing on the Prime Meridian line of the earth at Greenwich, England, and looking up at the transit instrument by which the time of the earth is set.

west to east, the time which elapses between the instant when the ray of light from the sun coincides with the axis of the telescope until it does so again is a solar day. It is understood, of course, that the telescope axis lies in the plane of the meridian.

The meridian at Greenwich, England, has been fixed as the prime meridian and a line is drawn on the ground representing this meridian. Fig. 8. Directly over this line is a transit instrument (telescope) by which time is taken from the stars in their apparent motion about the earth. The time it takes from the instant a star is directly over the prime meridian until it is again over the same meridian is called a sidereal day. If we take 1/86400 part of the sidereal day we obtain the sidereal second.

1 Sidereal Second = 0.99727 mean solar second.

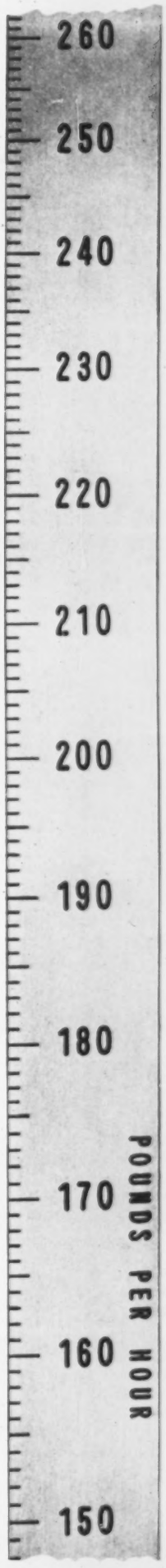
While we actually take time from the stars we still go by the sun, and use the mean solar second as our standard of time. We still worship the Sun!

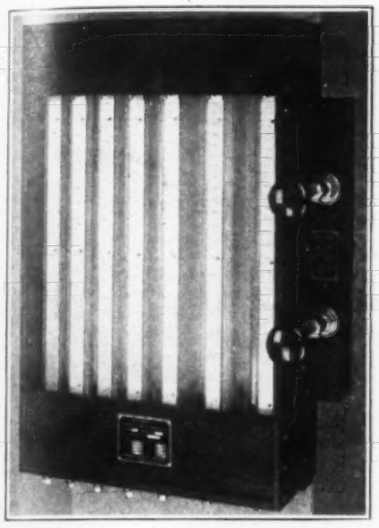
Our Standards for the fundamental units of measurement of physical magnitudes are, therefore:

The Meter for Length
The Kilogram for Mass
and The Second for Time

All other units are built up out of these fundamental units

HOW FAR CAN YOU READ THIS SCALE? →





This is one of seven scales used on a Type VII Multiple Stage Fluted Guide Flow Indicator. The total scale length for the seven stage instrument is 10½ feet within a space 18" wide by 18" high. The total flow range is from 5 to 4000 pounds of fuel per hour.

This Flow Indicator is Used Exclusively by the Largest Aircraft Carburetor Manufacturers.

The Fluted Guide Metering Tube, moulded of Pyrex glass, is the outstanding improvement in variable-area, flow rate indicators in recent years.

It is an exclusive feature and is the result of nearly twenty years experience in this field.

THE TYPE VII FLUTED GUIDE FLOW INDICATOR

SPECIFICATIONS

Weight	110 lbs.
Height	28¾ in.
Width	21 in.
Depth	7¾ in.

CAPACITY
(lbs. per hr.)
Type VII 5-4000
Type VIII 5-7000

Intermediate capacities are obtained by selecting any one stage or two or more consecutive stages.

• • •

COMMERCIAL ENGINEERING LABORATORIES

4612 WOODWARD AVENUE — DETROIT, MICHIGAN

Makers of

AIR FLOW INDICATORS, ENGINE INDICATORS, FUEL FLOW INDICATORS, MAGNETIC GAGES, PIEZO-RAY EQUIPMENT FOR PRESSURES AND VIBRATIONS, TORSIOGRAPHS AND OTHER FINE TESTING INSTRUMENTS.

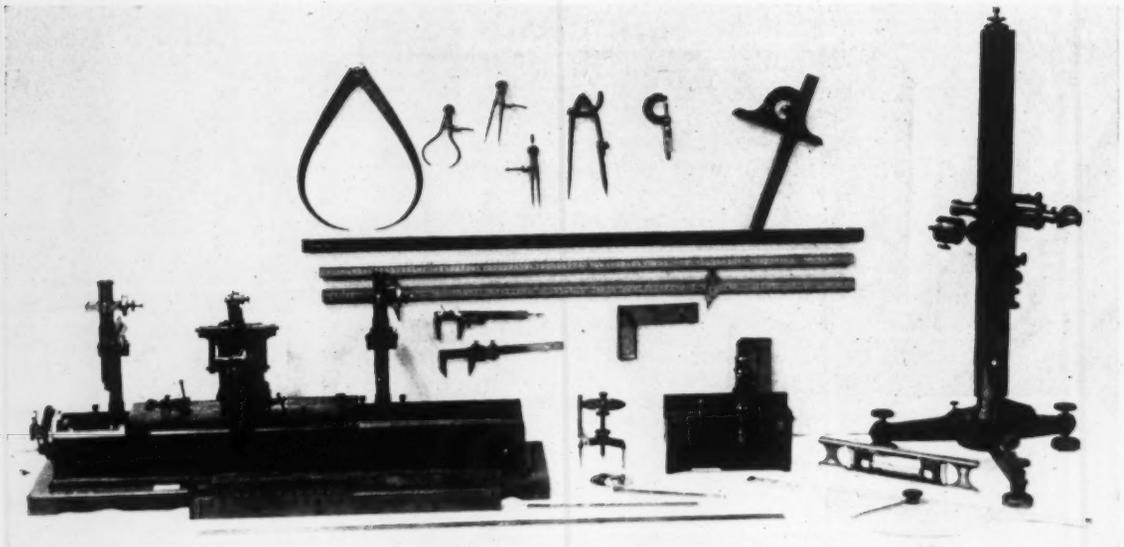


Fig. 9. LENGTH—Various devices for measuring length.

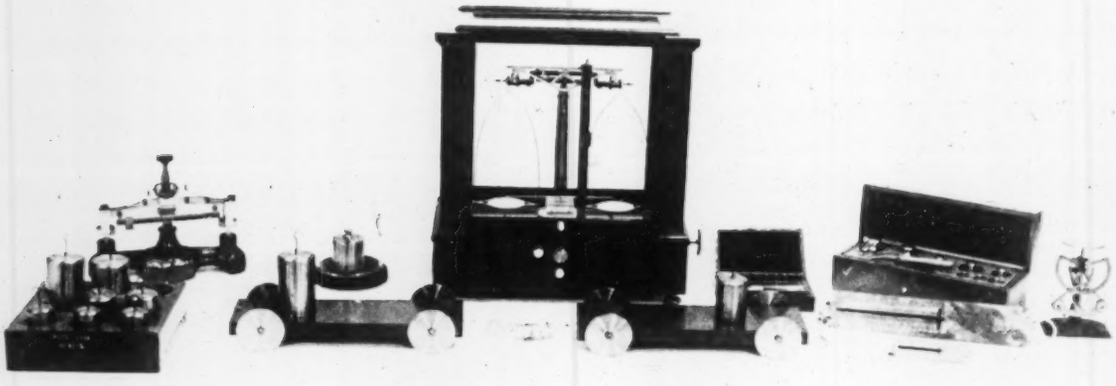


Fig. 10. MASS—Various devices for measuring mass.

In Fig. 9 are shown various devices for measuring LENGTH under different conditions. They may be listed as follows:

1. Carpenter's Square
2. Try Square
3. Standard Meter Bar
4. Micrometer Caliper
5. Vernier Caliper
6. Inside Calipers
7. Outside Calipers
8. Steel Measures
9. Wooden Scales
10. Carpenter's Folding rules
11. Cathetometer
12. Comparator
13. Level
14. Spherometer
15. Gravity Protractor
16. Model Vernier
17. Steel Tape
18. Compasses

Linear and circular dividing engines and range finders would constitute additional and interesting material.

In Fig. 10 may be seen items for measuring MASS:

1. Standard Kilogram
2. Sets of brass weights
3. Platform balances
4. Spring balances of various designs
5. Fine Chainomatic Balance
6. Letter scale
7. [illegible]
8. Inertia carts

Fig. 11 shows several devices for measuring TIME:

1. Metronome
2. Electric Clock
3. Tuning Forks
4. Stop Watches
5. Model Balance wheel
6. Steel Bars for Longitudinal Vibrations
7. Second pendulum actuated by weight and escapement
8. Model of earth with transits on it for taking time from the stars (See Fig. 7)

To these might be added the crystal oscillators now used in precision clocks and for controlling the frequency of radio transmitters.

In England and in general use in this country the Standards for the fundamental units of Length and Mass and Time are:

The Yard for Length
The Pound for Time
and The Second for Time

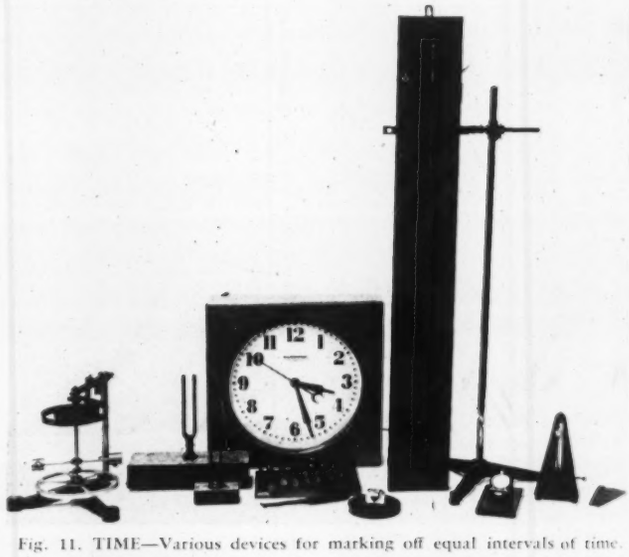


Fig. 11. TIME—Various devices for marking off equal intervals of time.

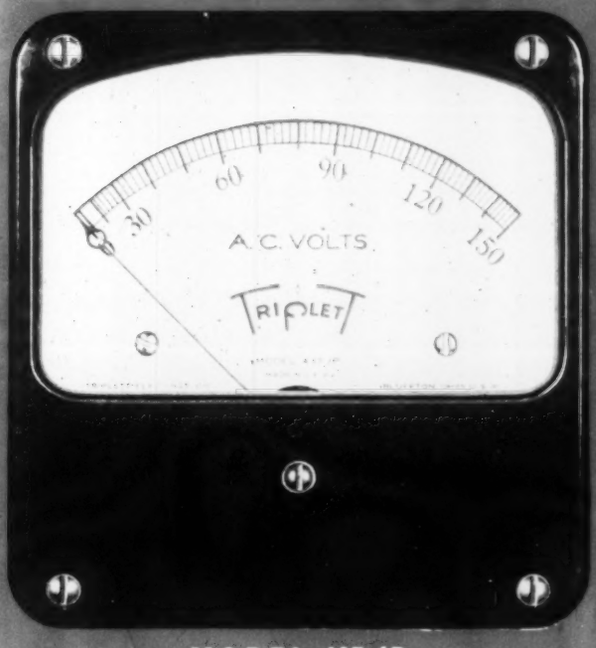
They are defined in a manner analogous to the Standards in the metric system, but are not officially recognized by the International Congress of Weights and Measures as are the Metric Standards. The physical embodiments of the standard yard and pound are preserved in London.

When we come to electrical units of measurements it will be seen that they are all based on Metric Standards, and are not based on the English units. The metric system of units is distinctly the units of scientific measurement.

TRIPLETT

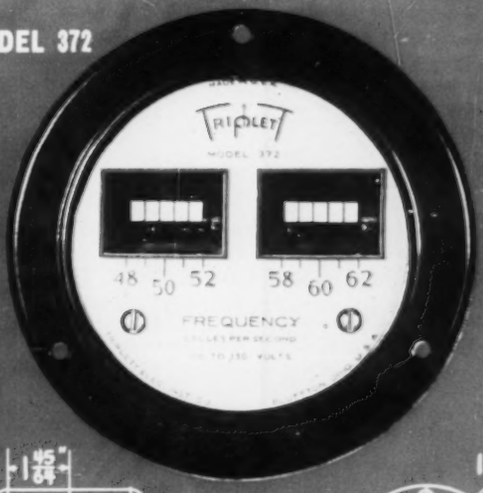
NEW *Combat Line* INSTRUMENTS

THESE PHOTOGRAPHIC REPRODUCTIONS ARE THREE-QUARTER SIZE



MODEL 437-JP

MODEL 372



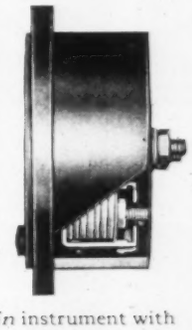
Model 437 - J P

SIMPLE INSTALLATION DIAGRAMS

Model 372

Maximum Service in Minimum Space

TRIPLETT *Thin Line* INSTRUMENTS



Precision performance by new *thin* instrument with *standard* Triplett movement housed in either metal or molded case. No projecting base; wider shroud to strengthen face; simplified zero adjustment; balanced bridge support; metal bridges at both ends; doubly supported core. For "Precision in limited space" write for Triplett Thin Line Bulletin.

The Triplett Combat Line

New Answers to specialized needs of War: Production Speed-up and Standardization; Performance under the Stress and Vibrations of Combat Service.

Model 437 J P—A rectangular line of meters to meet dimensions shown (see diagram). Wide-open scale for maximum readability. Complete coverage AC-DC Voltmeters, Ammeters and Wattmeters. Magnetic or static shielding provided on order. Molded Plastic Case for maximum protection in high voltage circuits. Pivots, Jewels and other component parts designed to meet severe vibration requirements.

Model 372—**Frequency Meter**—"All-American make" Vibrating Reed Frequency Meter. Maximum readability by grouping of Reeds. Range-Frequency-Voltage to meet specific requirements. Protected against excessive panel vibration. In standard 3 inch mounting or on special order in any cataloged Triplett Case.

A WORD ABOUT DELIVERIES

Naturally deliveries are subject to necessary priority regulations. We urge prompt filing of orders for delivery as may be consistent with America's War effort.

TRIPLETT ELECTRICAL INSTRUMENT CO.
BLUFFTON, OHIO

TRIPLETT

Some Pot Shots at This Relative Thing Called "PRECISION"*

By I. A. HUNT

Federal Products Corp., Providence, R. I.

MR. Chairman and gentlemen of the Precision profession. Please note I said profession—with due and proper consideration—because one who follows a profession is one who usually spends his time practicing rather than actually finishing anything. You know how it is with those who practice medicine, law, etc.: when they get through practicing on you, you are usually broke physically and mentally and financially and in a worse jam legally, as the case may be.

In your case it may be a little different; nevertheless, you do *practice* precision because you never really *are* precise. You used to think you were precise when you hacked away with a file and you think you are now because you've got used to looking at thousandths and tenths of thousandths of an inch in the face without getting cold feet. But don't forget there are still millionths to fool around with. So it's all very relative, this thing called precision.

Human beings are so prone to say "*no*" to new ideas. We know the old ideas, our old habits, our old tricks and our old methods but we argue back when it comes to the new idea. A man with an idea is so often a prophet without honor in his own country or shop. In spite of all this, I

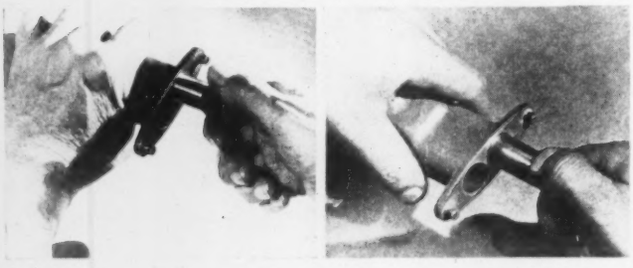


Fig. 1

propose to offer you a few interrupting thoughts. I will proceed to take the shirt off the obvious, and display it in all its nakedness for you to observe. I frankly admit that I am going to attempt to sell you an idea or two and in doing so, I will have to talk selfishly, for after all *precision* is our business and yours. We are all interested in it as never before to the *n*th degree.

What is Right?

Across the top of one of the tremendous airplane plants in this country there is, or there was, a mammoth sign hundreds of feet long which read as follows: "Nothing Short of Right is Right." The older I get the more difficult I find it is to know just what is right. I believe determining what is right is the biggest job you engineers have to do. Yet what a tremendously relative thing it is, this matter of what is right. Dr. Einstein has little on us!

It is not my intention to explore theoretical labyrinths. There is of course a definite need for such discussions, but I am not the man to do it. On the other hand, you engineers need to have your noses pulled off the grindstone now and then in order to take a look at what's around.

As I say the word "precision," each one of you has a different conception of the word, according to your experience with it. Some of you undoubtedly have a far greater idea of precision than I have: you have fussed with it, sweated over it and licked it. Others of you haven't seen anything yet.

*A talk delivered before the Hartford Society for Measurement and Control, Hartford, Conn., Sept. 15, 1942.

It is a truism that no two men are alike. This is true in general and it is true of machine operators, or of inspectors. They have different degrees of nervous and muscular endowments. Their nerves tell them how a gage feels on the workpiece. And yet you expect them to inspect down to thousandths of an inch and finer. You set up tolerances for the workpieces that have got to fit one another and you set up limits for the fit itself. These you determine by a consideration of the requirements of the finished job based on the quality, the material, the cost. You consider the wear on the gages themselves, you consider temperatures, but what, and how much, do you allow for the man—the human being who is going to sit in judgment of those pieces of work? Fig. 1 shows the hands of two men, one sensitive and the other sluggish or heavy.

The sense of touch is indeed a very relative thing. It cannot be magnified except by training, which takes time; and skill, which varies even after training. Look around your own shop and see if it doesn't. Vision is also relative, but we correct it with eye-glasses. But did you ever see anything that magnified the sense of touch? Visual gages magnify facts so you can see them. That is why visual gages have leaped ahead. There are so many reasons for visual gages that you haven't thought about, that I believe I shall be pardoned if I tell you about their possibilities. We are all interested in winning this war—in getting things done faster and sufficiently right to meet the need. If I can show you how to avoid inspection trouble, how to

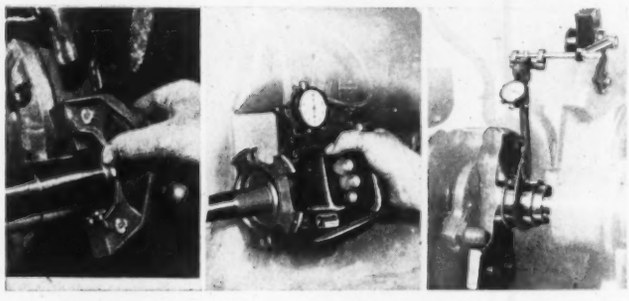


Fig. 2

inspect more accurately and faster, I believe you will pardon my sticking to one subject which I am in a position to observe from many angles.

In Fig. 2 you see three illustrations emphasizing the importance of visual gages. The gage at the left is mute. Think of a blind man as he reads his Braille book with raised letters. You undoubtedly regard him with pity; yet you still provide many inspectors with Braille type gages, so to speak. Or have I given you an idea here? Why not try out some blind men as inspectors? Maybe their highly-developed sense of touch would be a big improvement. For after all I must admit, though reluctantly, that feeler gages do have an economic place in inspection.

But notice how the middle gage automatically tells you visually how right or wrong you are.

And then look at the gage on the right. Here you watch the work grind down to size; you don't stop to mike it; you don't over-grind. Result, you save time, you save stock and you produce more and right.

The Human Element Is Too Often Forgotten.

Two points stand out in the articles and discussions I have read and listened to concerning gaging. One is, that in almost every article on precision maintenance the mechanic

details are carefully covered but the human element is seldom touched upon. Fig. 3 is a list which appeared in an article by Mr. Hitchcock in *Modern Machine Shop*. It gives twenty-one human factors all of which tend to cause failure to do work as required. Twelve of these twenty-one causes

TABLE I

	Underlying Cause	*Weight*
1.	Negligence	339
2.	Speed	265
3.	Over confidence	217
4.	Lack of knowledge	214
5.	Worry	208
6.	Thinking of things foreign to the job	192
7.	Improper supervision	168
8.	Physical defects of men	160
9.	Fear	150
10.	Defective equipment	144
11.	Lack of cooperation	142
12.	Wrong mental attitude toward safety	140
13.	Horseplay	106
14.	Misunderstanding of orders	91
15.	Disobedience of orders	61
16.	Lack of emotional control	56
17.	Poor judgment	51
18.	Bullheadedness	42
19.	Lack of interest	36
20.	Recklessness	25
21.	Outside interference	15

Fig. 3

can be directly associated with inaccurate gaging and all twelve are directly due to the human element.

You set up carefully considered standards; you take all kinds of care in setting standards; but it is my observation that you do not often enough remember the human element.

Wear

On the other hand, a factor which I do find mentioned time and again is that of wear. Now everything wears. Gages are no exception. Solid gages when worn are no longer of any use. Visual gages, on the other hand, although they can and do wear, can be reset. Consequently wear does not stop their continuous use.

How Gage Applications May Be Classified

There are of course thousands of gage designs. Federal has in its files over 6,000 special designs. When I mention these thousands of designs you probably imagine thousands of dimensions. Yet, all of these classify themselves into a few simple dimensions. The following is my adaptation and elaboration of an original classification by Capt. R. A. Bowman of the Pittsburgh Gage Laboratory of the Army, as published in *Instruments*:

1. *Inside Dimensions* (Including roundness)
   Cylinders, holes, inside dimensions of recesses, in castings, forgings, bottles, patterns.
2. *Outside Dimensions* (Including roundness)
   Shafts, pitch diameters, thickness, width, parallelism.
3. *Offset Dimensions*
   Depths of slots, splines, height of bosses, flanges, etc.
4. *Alignment or Position Dimensions*
   Location of holes, studs and other details.
   Concentricity or eccentricity of diameters.
   Lead of threads, etc.
   Straightness.
5. *Angle*
   Tapers, bevels, etc.
6. *Profile*
   Roundness, chamfers, fillets, cams, shell ogives.

Proper Use of Dial Indicator Gages

I shall now comment on some phases of dial indicator gages. I am compelled to show you photos taken largely of our own gages, because of the difficulty in obtaining photographs in outside plants under present conditions.

One of the most common faults in applying Dial Indicators is the carelessness in maintaining *rigidity*. This is one of the most common mistakes found in the application of dial indicators. The indicator should not be supported by a slender rod, too far away from the indicator, allowing the rod to spring. In such a case the indicator, unless it is a very sensitive one, may not move until after the rod has begun to bend, with the result that the inaccuracy of the work will not be indicated in the indicator. This is most deceptive on a piece of out-of-round work where the change is gradual. There are other cases similar to this where rigidity is too often neglected. It may not be a rod which is too flexible to support the indicator, it may be in the structural design of the gage itself.

Concentricity

Inspection of parts for concentricity and diameter is frequently misunderstood, due to habits formed by some users. It is a fact that men will put work in a single comparator and check it for diameter and roundness; but when it comes to checking a piece with *more than one diameter*,

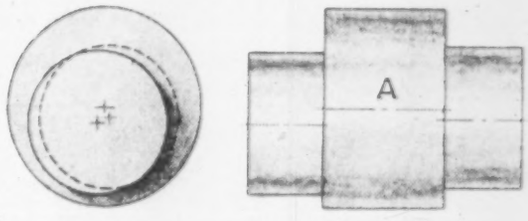


Fig. 4

they make the following mistake. This is best illustrated in the case of shell inspection which is so important at the present time. Assume that we have a piece similar to that illustrated in Fig. 4. There are three diameters, and we want to inspect them for concentricity with each other and for diameter. If we place these pieces in a V block and check them for concentricity with each other, as shown in Fig. 5, our inspection will be quite all right. The V block acts as a reference point as well as a support to the workpiece. The indicator then shows up any lack of concentricity

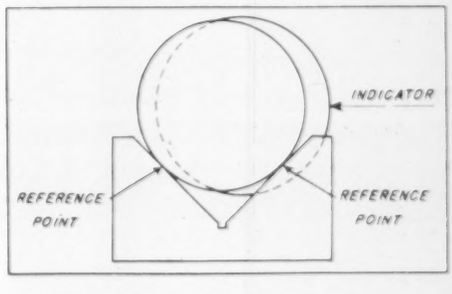


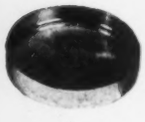
Fig. 5

or of the eccentricity of the diameters, in other words. But the mistake is that men also try to inspect several *diameters* with this same arrangement, and it cannot be done.

In order to inspect each diameter with indicators placed on these various diameters it is absolutely necessary that the diameters be concentric with one another, but this is seldom the case. In order to inspect for diameter, each of the different diameters must be inspected *separately*, and this we do as shown in Fig. 6. Here the reference points and the indicators for each one of the different diameters

ARMY
E
NAVY
It is OUR duty
The Coveted Army-Navy Production award has been presented to the patriotic men and women of the Barbour-Stockwell Company; a glowing tribute to the high records attained in the production of war equipment.
In the letter of citation received from Robert P. Patterson, Under Secretary of War, Mr. Patterson said in part—
"This award is your nation's tribute to your patriotism and to your great work in backing up our soldiers on the fighting front. I have full confidence that your present high achievement is indicative of what you will do in the future."
We accept this honor with full appreciation of our responsibility . . . and, speaking for our associates . . . each and every man and woman who proudly wears the "E" Award Pin, feels it is his patriotic duty to exert every ounce of strength in this supreme war time effort of all-out production; and further pledges that if more production records CAN be broken, they WILL BE BROKEN.
BARBOUR STOCKWELL CO.
BSC
CAMBRIDGE, MASSACHUSETTS

RAPID — ACCURATE
MOISTURE CONTROL
with the
DIETERT
MOISTURE TELLER



Time required to dry majority of materials is one minute

Many Uses
SAND — COAL — SALT — TEXTILES
WOOD—CERAMIC—SUGAR—FOOD

Write for Literature

HARRY W. DIETERT CO.
9330-C ROSELAWN AVENUE, DETROIT, MICHIGAN

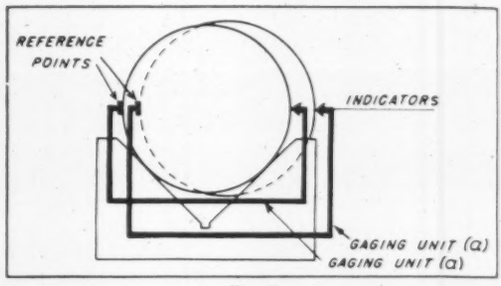


Fig. 6

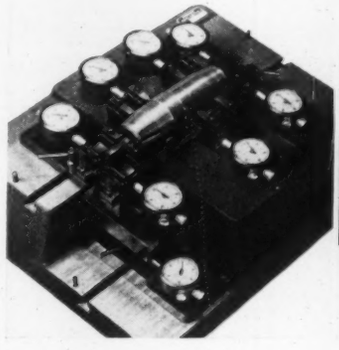


Fig. 7

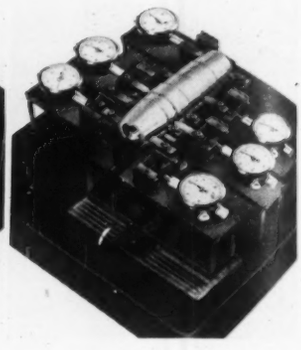


Fig. 8

are each a single and independent unit. The V block acts merely as a support.

How this appears in actual gages is shown in Fig. 7 which is a concentricity gage and Fig. 8 which is a diameter gage. Note the flat springs which support the indicator units in the latter illustration. Also note on the concentricity gage how nine diameters are being inspected simultaneously: both inside and outside diameters.

In designing dial-indicator gages, friction, inertia and lost motion are all too frequently ignored. Fig. 9 illustrates that point very well indeed. This early experimental design has several bad features about it. In the first place the rocker arm which measures the concentricity of the inside of the shell consists of a long heavy bar of cold-rolled steel; such a heavy bar cannot be very sensitive because it is bound to have a lot of inertia. In the second place it is mounted on a stud, and the weight of this bar causes a great deal of friction on that stud. In the third place there is bound to be some play or lost motion in the fit between the bar and the stud. All these three items cause inaccuracy so that the motion of the contact point which touches on the shell is not transferred accurately to the indicator.

Note that the shell master rests on ball bearings or roller bearings. These bearings must of necessity have some clearance so that they will rotate. Here is a chance for inaccuracy in the bearings themselves. The shell is not heavy enough to warrant the use of these bearings. A much larger

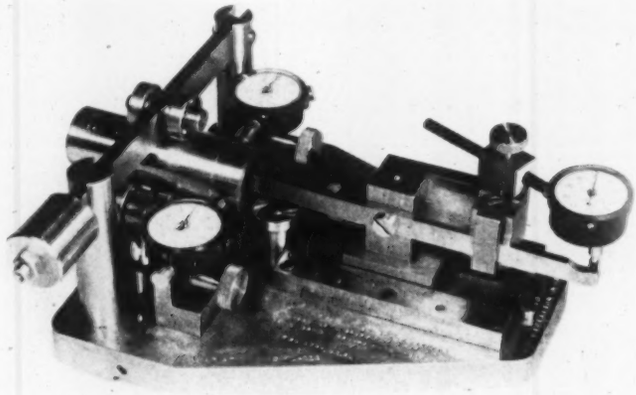


Fig. 9

shc than this could easily be mounted on solid V blocks wh h would be more positive than the bearings.

Note also that all indicators are rather crudely mounted, and the stems of the indicators are not protected in any wa so that unless the shell is placed in the gage carefully, the spindles of the indicators can be easily bent through carelessness, causing an increase in friction and inaccuracy.

On the other hand, note that the indicators on the two previously-shown shell gages (Figs. 7 and 8) are protected with stops so that if a shell is carelessly placed in the gage, it will not push the contact points beyond the range of the indicator—a condition which would naturally cause undue pressure on the mechanism of the indicator. Also notice that the indicators themselves do not contact the work but that auxiliary contacts come between the indicator and the shell, thus eliminating any side thrust on the indicator rack spindles which would cause friction or binding of the rack spindle resulting in inaccuracy.

Entirely too often, gage engineering inspectors and men in a similar capacity seem possessed with the idea that dial indicators, or any other visual gages for that matter, are to be used simply for great accuracy. We frequently hear the objection that the work is not accurate enough to require the use of dial indicators.

One of the most popular gages we manufacture is not known as an accurate gage at all. It is the most popular gage because it is so handy and convenient that it is easier to use it than it is to take a chance. This is a caliper gage with a dial indicator attached. This gage has been used for checking everything from the thickness of the walls of glass bottles to the thickness of walls of airplane engine cylinders (Fig. 10).

Fig. 11 illustrates another way in which time can be saved through the use of dial indicators. Imagine trying to inspect the inside of a bushing for diameter, roundness and taper; and at the same time inspecting the outside diameter

(Continued on Page 542)

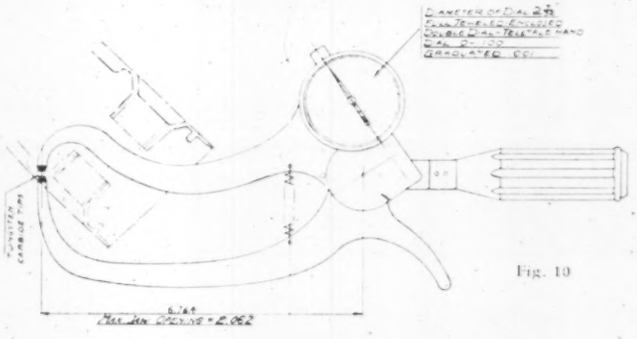


Fig. 10

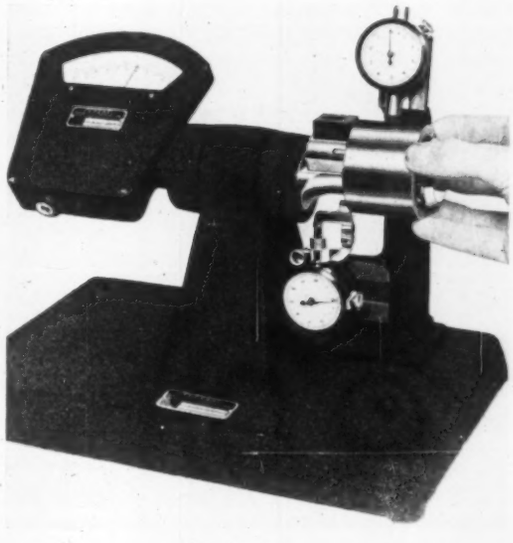


Fig. 11

MOELLER

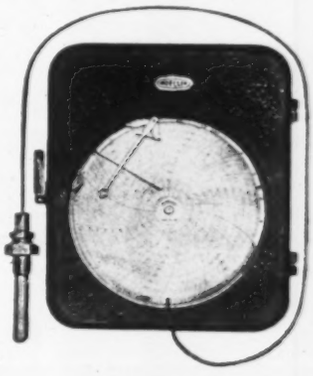
PRECISION GRADE INSTRUMENTS

☆

MOELLER MERCURY THERMOMETERS

Made with "Moeller Glass Red Reading Column," making them easy to read under varying light conditions, at a considerable distance and over a wide range.

MOELLER DIAL THERMOMETERS. Made in various scale ranges up to 1000°F. or equivalent. Metal and Phenolite cases.



MOELLER RECORDING THERMOMETERS

Furnished in various ranges up to 1000°F. or equivalent. Round or square cases.

Also HYGROMETERS
RECORDING PSYCHROMETERS
BAROMETERS HYDROMETERS
MARINE INSTRUMENTS, ETC.

Write for catalog.

MOELLER INSTRUMENT COMPANY

132nd STREET and 89th AVENUE
RICHMOND HILL NEW YORK

Sales Representatives in Principal Cities

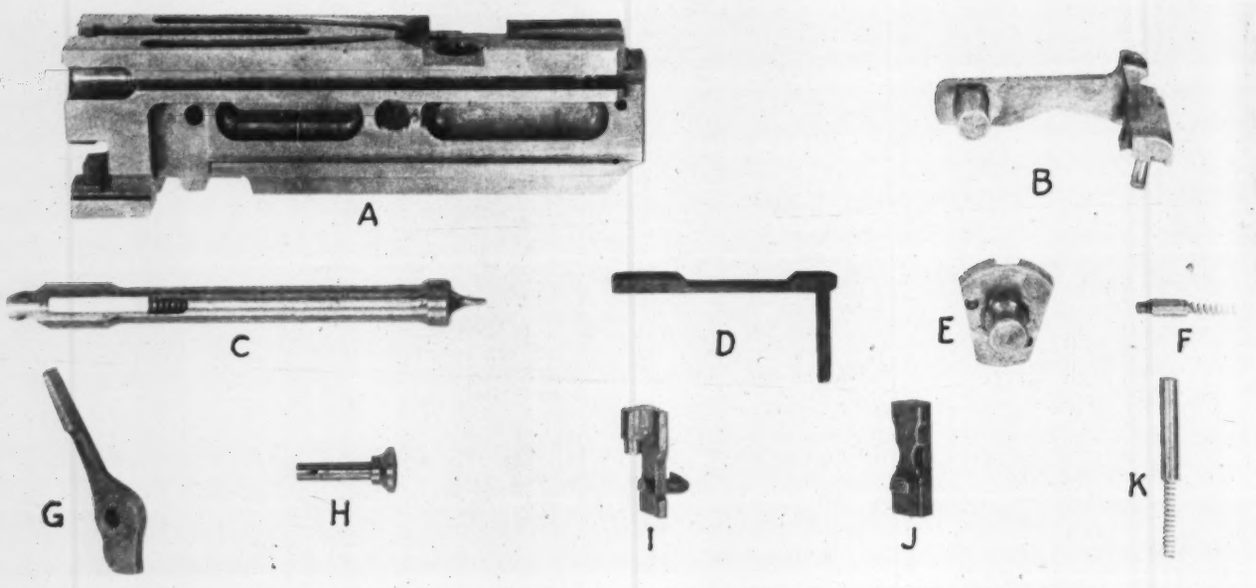


Fig. 1. Some of the 189 parts of the familiar "M 1919" (or "Browning") .30 caliber machine gun. A—bolt; B—extractor; C—firing pin and spring; D—sear stop; E—bolt switch; F—bolt switch plunger and spring; G—cocking lever; H—cocking lever pin; I—sear (with plunger and spring); J—sear holder; K—sear holder spring and plunger.

Methods and Equipment for the Inspection of Machine Gun Parts and Assemblies

By C. G. NELSON

Quality Engineer, Colt's Patent Firearms Mfg. Co., Hartford, Conn.

IT was the ingenious Eli Whitney who simplified the manufacture of muskets by standardizing component parts through the use of gages. Colonel Samuel Colt was one of the first to adopt this method in the manufacture of his revolvers. Thus were laid the foundations of modern gaging and inspection methods whereby manufactured components are standardized to the point of *complete interchangeability*. For many years Colt's enjoyed the distinction of being the only manufacturer of machine guns on this side of the Atlantic. Today the mating parts of the most intricate machine gun fit properly even though they are made in factories thousands of miles apart.

Today as in the days of Whitney and Colt, however, there is still one factor which cannot be predicted: the human element. This calls for the development of gages which are foolproof and easy to understand, and for the training of inspectors in the intelligent use of gages. It always has been a two-fold problem. War intensifies both aspects of this problem. In a year and a half our inspection staff has grown from 270 to 1500. Moreover, most of our inspectors have averaged only six to seven months' service to the company, because of the rapid turnover due to the draft. Our methods and our gages *must* be foolproof!

Still another factor which compels us to keep on improving both our training methods and our inspection methods is the enormous number of operations on an enormous number of different parts. Our principal products at this time, as many readers know, are the .38 caliber revolver, the .45 caliber automatic pistol, and various types of .30 and .50 caliber machine guns.

The .30 caliber water-cooled machine gun, for example, is made in several types. The familiar type mounted on a tripod and firing 5-600 rounds per minute contains 189 pieces. The .30 caliber air-cooled machine gun, used in combat vehicles and also in airplanes as either a flexible or fixed gun, fires 1350 rounds per minute. Various types of these guns will contain up to 250 pieces. Also in the caliber .30 class is the Browning automatic rifle, used as either a semi-automatic or a light machine-gun.

In the .50 caliber or heavy class, are the water-cooled tripod-mounted machine gun; and for use in aircraft and combat vehicles various air-cooled types capable of firing 900 rounds per minute. These .50 caliber guns have even more parts than corresponding types of .30 caliber guns.

Fig. 1 shows some (about one-half) of the parts of the "bolt group" of a .30 caliber machine gun. The mere description of the "bolt group" occupies several pages in the gunner's manual, so I shall not attempt it in this article. The reader will gain some idea of the inspection problems from a careful scrutiny of Fig. 1. I may mention, however, that it takes nearly 140 operations to produce this bolt (A) from raw bar stock. For machining alone, more than a hundred gages must be applied to it, some operations requiring 100% inspection at the machines—all this before the bolt is filed, heat-treated, the holes lapped and the ways ground, these operations requiring the use of about forty more gages. When the bolt has been finish-machined, final inspection takes over with about thirty-two more gages, which sum up all the key-points.

Most of our larger pieces are made from forgings, which are given 100% inspection for surface defects, form, and general perfection. When the forgings have passed inspection they are either annealed or toughened before machining. Since heat-treatment is done in batch furnaces or continuous furnaces with modern instrumentation to assure uniformity, only fractional inspection is ordinarily given for the correct Brinnel or Rockwell. These parts now having been heat-treated, they are moved to the Blanchard grinders, where 100% inspection is conducted.

Screws, pins, studs and rivets can be given a fractional inspection, say 10%, but practically all other parts—not only the large ones made from forgings but all the small *functional* parts—require 100% inspection at different operations along the line. For this, inspectors are stationed at the machines, each inspector passing on the work of several similar machines as it is produced.

Final inspection of sub-assemblies and groups requires special equipment and special methods.

Now the reader will not be astonished when I mention that the production of all parts for all guns keeps an in-

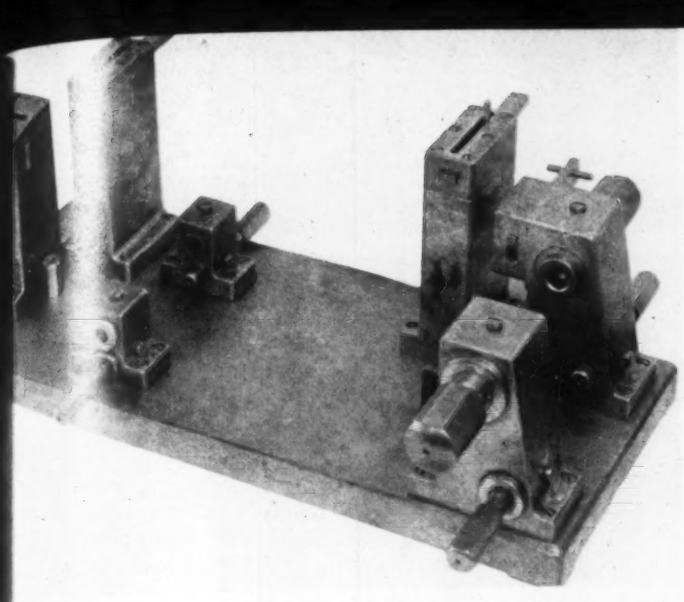


Fig. 2

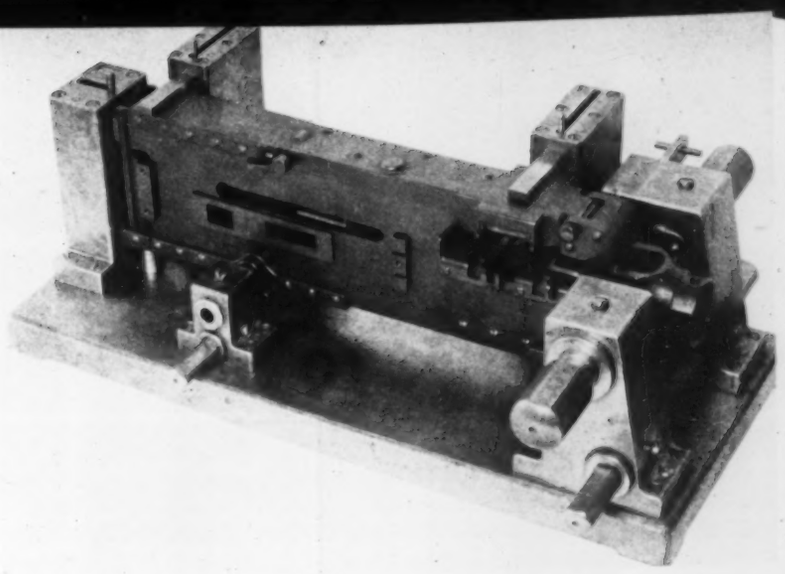


Fig. 3

spection crew busy twenty-four hours a day every day in the week.

In the remainder of this article there will be described a few examples of special inspection equipment. Needless to say, Colt's has a large number of *measuring* instruments, including recorders, but the readers of *Instruments* are already familiar with these standard items of laboratory and plant equipment. Moreover, the great majority of inspection operations are determinations rather than absolute measurements. These determinations must be made decisively: the answer must be "yes" or "no" without guesswork. These determinations must be made rapidly: there is no time to squint at a vernier or even to observe where a needle intersects the graduations on a dial. These determinations must be made by inspectors many of whom had never handled precision devices before: the equipment must be rugged, simple and designed to prevent "fatigue errors" toward the end of each shift.

Guns are different from other mechanisms, in that instead of taking measurements from a base line, dimensions are usually checked from a reference point which experience has shown to be the point from which to begin.

In airplanes, for example, the gun-mounts are welded in place. This means that we must have all guns standardized for quick replacement. The 12-point gage shown in Fig. 2 checks this, along with alignment and overall dimensions, also checking the position of the feedway, which must be held to a close tolerance, relative to the mount. Fig. 3 shows the gage in use. A comparison of Figs. 2 and 3, point by point, will reveal how the various sliding gaging members determine a number of positions and alignments.

Timing is just as important in a machine-gun as in an internal combustion engine. To guarantee that the timing will be within prescribed limits, the position of the trigger must be gaged in the case before assembly. In the fixed aircraft gun, the trigger is an electrically-controlled unit, clamped onto the gun, and operating from either side. In Fig. 4 we see the gage in position, checking the position of the sideplate-trigger slot relative to the trunnion block. The step in the sliding plug allows 0.010" tolerance. The

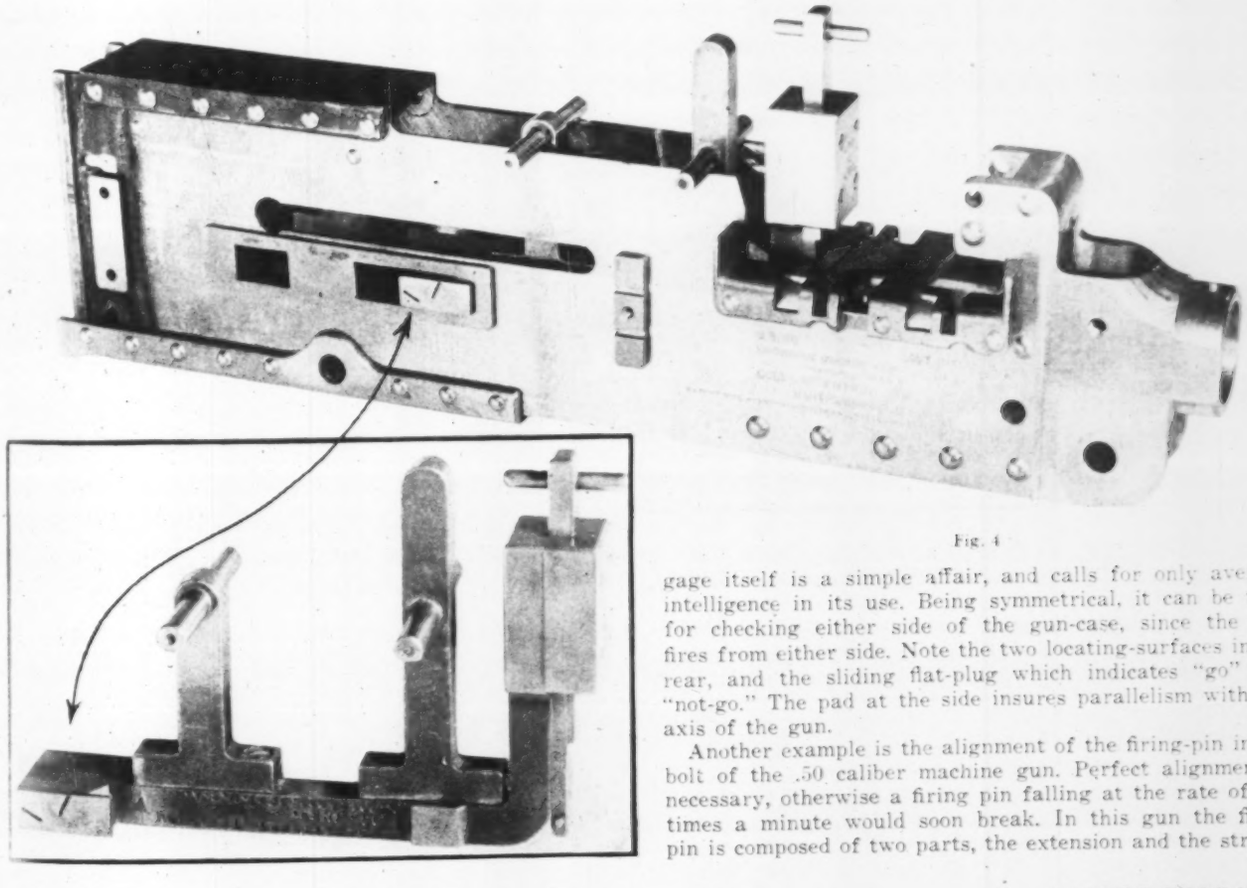


Fig. 4

gage itself is a simple affair, and calls for only average intelligence in its use. Being symmetrical, it can be used for checking either side of the gun-case, since the gun fires from either side. Note the two locating-surfaces in the rear, and the sliding flat-plug which indicates "go" and "not-go." The pad at the side insures parallelism with the axis of the gun.

Another example is the alignment of the firing-pin in the bolt of the .50 caliber machine gun. Perfect alignment is necessary, otherwise a firing pin falling at the rate of 900 times a minute would soon break. In this gun the firing pin is composed of two parts, the extension and the striker.

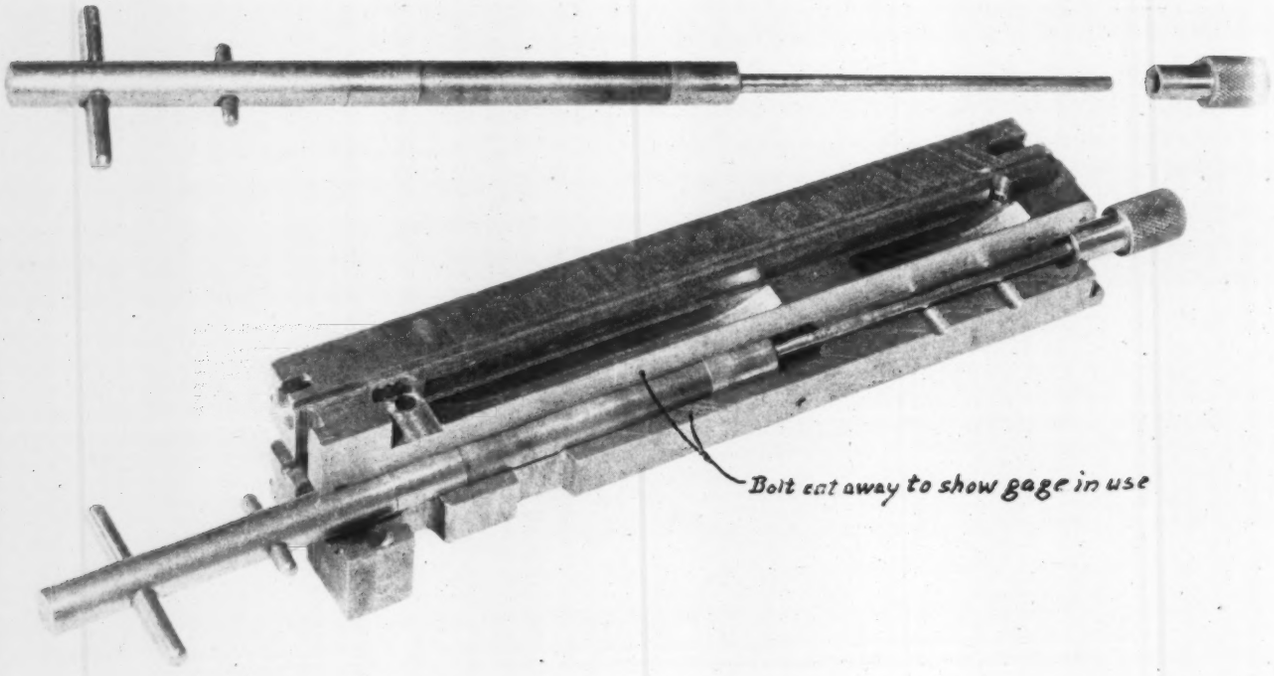


Fig. 5

Both parts must slide freely in the bolt, through which there is a shouldered hole. The gage shown in Fig. 5 anticipates this condition. The bushing provides the means of checking the alignment of a hole in the face of the bolt, which takes a hardened insert called the recoil plate. This simple gage then indicates the alignment of no less than three holes, yet it can be used to good advantage, quickly and with no great skill involved.

In order to insure that firing-pins will strike the center of the primer, alignment must be checked between the bolt-ways and the recoil plate. If it were not for the simple receiver-gage shown in Fig. 6, this job would be one for a toolmaker. The gage holds the bolt in position to be checked by the pin.

There are five barrels turned out for every gun produced. This means that inspection must be quick but correct. Among other requirements, the barrel must be perfectly straight. In order not to depend only upon the eyes of the experts who do the straightening, we use a drop-plug after both reaming and rifling. This plug is a solid steel cylinder 8" long for the .30 caliber and 12" long for the .50 caliber. In either case, this plug must drop freely through the barrel, yet it fits with a maximum clearance of 0.0017" and a minimum of 0.0002".

Another point in the barrel, which must be carefully watched, is the chamber. The surface of the chamber must be perfectly smooth so that the high pressure of the burning powder, which amounts to 28 tons per square inch, will not force any of the brass of the cartridge-case into grooves or tool-marks. If this were to happen, automatic extraction of the empty case would be impossible and the gun would cease firing. For this reason, we employ visual inspection of the inside of the chamber. Since the hole is small, and dark inside, we use a small reflector, Fig. 7, which can be placed at right angles to the bore in such a way that the inside is illuminated, thereby allowing flaws to be detected. Fig. 8 shows a barrel cut-away to show the chamber and the reflector.

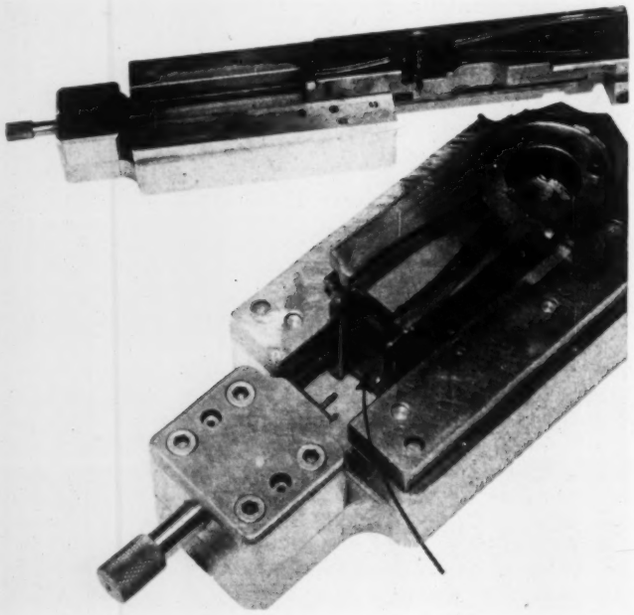


Fig. 6

Fig. 7

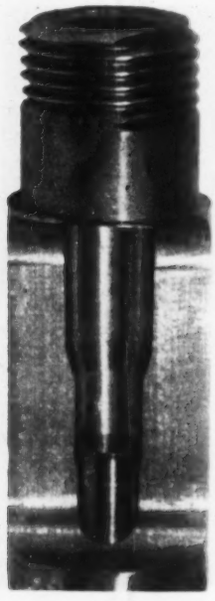


Fig. 8

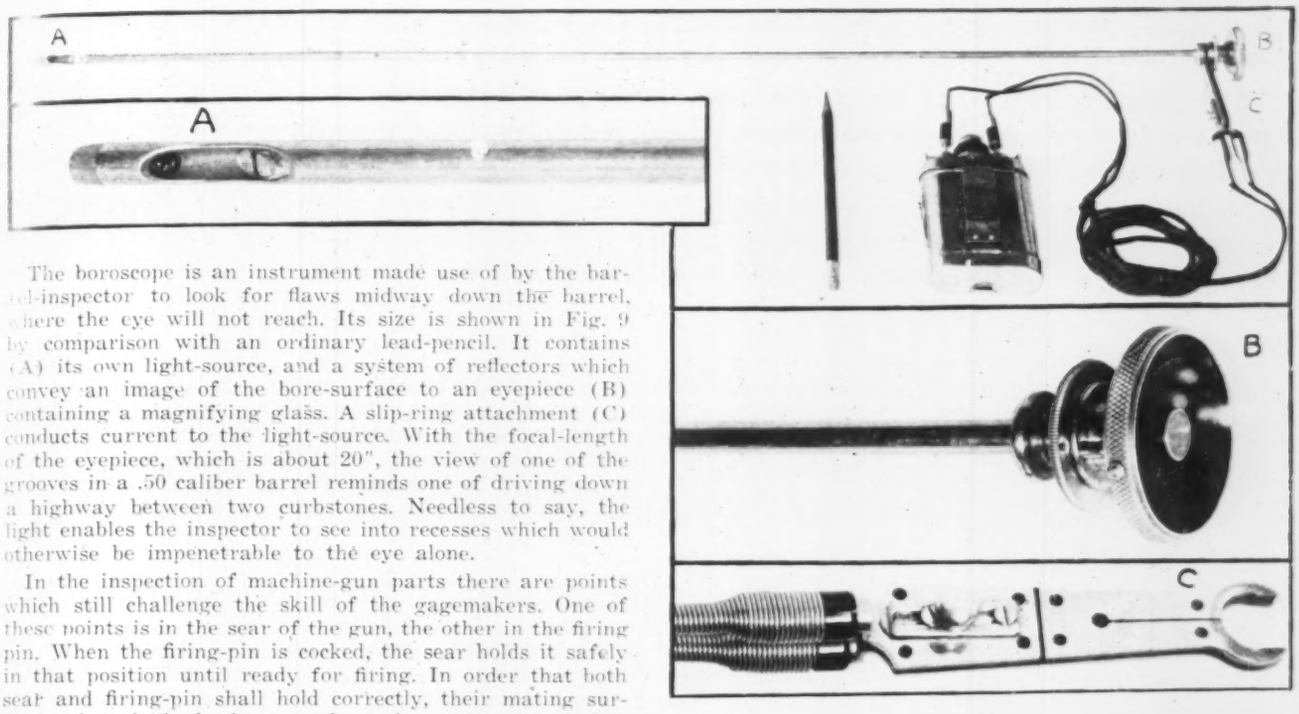


Fig. 9

The boroscope is an instrument made use of by the barrel-inspector to look for flaws midway down the barrel, where the eye will not reach. Its size is shown in Fig. 9 by comparison with an ordinary lead-pencil. It contains (A) its own light-source, and a system of reflectors which convey an image of the bore-surface to an eyepiece (B) containing a magnifying glass. A slip-ring attachment (C) conducts current to the light-source. With the focal-length of the eyepiece, which is about 20", the view of one of the grooves in a .50 caliber barrel reminds one of driving down a highway between two curbstones. Needless to say, the light enables the inspector to see into recesses which would otherwise be impenetrable to the eye alone.

In the inspection of machine-gun parts there are points which still challenge the skill of the gagemakers. One of these points is in the sear of the gun, the other in the firing pin. When the firing-pin is cocked, the sear holds it safely in that position until ready for firing. In order that both sear and firing-pin shall hold correctly, their mating surfaces, shaped like hooks, must be undercut to prevent slipping. If this were not so, uncontrolled fire would result: the gun would run wild until the ammunition was exhausted.

To check this undercut, we now find it easier to use a shadowgraph than a steel gage of any kind. Not only does this reduce errors in judgment, but it permits volume handling not slowed down by the use of a standard gage.

The shadowgraph also pays for itself in checking firing-pin strikers. The striker must be smooth and ball-shaped in order not to puncture the primer. In the event that a rough striker found its way into a gun, the primer might rupture, and the resulting blow-back of gas could injure the operator. Fortunately, the shadowgraph will magnify any irregularity in the shape of the striker. It will also show whether the striker is bent as it is rotated in its support in the machine, thus accomplishing two purposes, which would otherwise take both time and skill.

From these few examples it might be inferred that Colt's is attempting to do away with skilled labor. Not at all. We still have a few skilled workmen. One of the choice jobs I have in mind requires working to zero tolerance. Surprising as this sounds, it is nevertheless true, since fitting barrels to revolvers requires just that. The front sight is brazed to the barrel before finishing. This means that the workman must qualify his threads in order to bring the sight up to correct position. One thousandth of an inch off would cause an inaccuracy in shooting of seven-eighths of an inch at 15 yards. All our guns are fired and targeted before passing final inspection, and let it be said now that an error of this size is simply not tolerated.

Of course we have some scrap. Every modern factory, no matter how well manned or equipped, will admit this. Yet it is because of the efforts of such men as Whitney and Colt that modern American production methods have reached the point of turning out more precision machinery and better engines of war than the world has ever seen.

STOP!

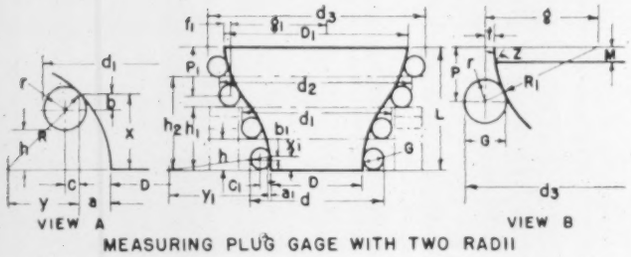
Stop a moment for an urgent reminder and for TWO important NEW announcements . . . Excuse our "shouting" this way on an otherwise impeccable page of your favorite technical magazine, but this concerns you . . . The Call for Ideas on Speeding War Work was first published in our October issue and the response has been good (you ought to see the pile of special-delivery and air mail that came in today, the closing date, December 7th)—but not good enough! For example the President of a company which designs, makes and installs War Work Speed-Up devices promised us that he would send in some descriptions—but we have not received a single manuscript from him! He probably started his write-ups but did not finish them because he was too busy. So did you and so were you. Therefore the closing date is postponed to December 31. That's the first new announcement. The second is that cash will be paid for all War Work Speed-Up Ideas published in *Instruments*. Two dollars minimum for a brief description without diagrams; one or two additional dollars for each diagram, photo, etc. Our idea is not to pay for ideas (that's impossible) but simply to cover the preparation costs—expenses usually paid personally by an author who does not have the services of his company's typists, draftsmen or photographers. As good Americans, our readers don't want money for describing the War Work Speed-Up methods they know of. However, some may have been discouraged when they learned what professional typists, draftsmen and photographers charge.

Now then, hop to it! There's only a few days left. Although the closing date is the 31st, please send your description before Christmas so that your overworked editor will not suffer a break-down putting *your* article in the big January issue.

Ordnance Production Gaging

By CAPTAIN RUSH A. BOWMAN

In charge of Pittsburgh Gage Laboratory, Ordnance Department, U. S. Army



MEASURING PLUG GAGE WITH TWO RADII

D = SMALL DIAMETER OF GAGE
D_1 = LARGE DIAMETER OF GAGE
R = RADIUS AT SMALL END OF GAGE
R_1 = RADIUS AT LARGE END OF GAGE
G = DIAMETER OF MEASURING ROLLS
r = RADIUS OF MEASURING ROLLS = $\frac{G}{2}$
L = LENGTH OF GAGE
M = DISTANCE FROM TOP OF GAGE TO CENTER OF ORIGIN OF RADIUS
h, h_1, & h_2 = HEIGHT OF GAGE BLOCKS ON WHICH ROLLS REST
d, d_1, d_2 & d_3 = MEASUREMENT OVER ROLLS

FORMULAE

$(R-r) : (h+r) = R : X$

$X = \frac{R(h+r)}{(R-r)}$ $\quad X_1 = \frac{Rr}{(R-r)}$ $\quad P = (L+M)-(h_2+r)$

$Y = \sqrt{R^2-X^2}$ $\quad Y = \sqrt{R^2-X_1^2}$ $\quad P_1 = (L+M)-(h_1+r)$

$a = R-Y$ $\quad a_1 = R-Y_1$ $\quad g = \sqrt{(R_1+r)^2-P^2}$

$b = X-(h+r)$ $\quad b_1 = X_1-r$ $\quad g_1 = \sqrt{(R_1+r)^2-P_1^2}$

$c = \sqrt{r^2-b^2}$ $\quad c_1 = \sqrt{r^2-b_1^2}$ $\quad f = g-R_1$

$f_1 = R_1-g_1$

$Z = R_1 - \sqrt{R_1^2-M^2}$

$d = D+G+2a_1+2c_1$

$d_1 = D+G+2a+2c$

WHERE d_2 IS LESS THAN D_1+G $(d_2 = D_1+2Z+G-2f_1)$
WHERE d_2 IS GREATER THAN D_1+G $(d_2 = D_1+2Z+G+2f_1)$ (IN THIS CASE $f_1 = g-R_1$)
WHERE d_3 IS LESS THAN D_1+G $(d_3 = D_1+2Z+G+2f)$ (IN THIS CASE $f = R_1-g$)
WHERE d_3 IS GREATER THAN D_1+G $(d_3 = D_1+2Z+G+2f)$

NOTE – ROLLS FOR d_1 MEASUREMENT MUST NOT BE ABOVE AND FOR d_2 MUST NOT BE BELOW POINT OF INTERSECTION OF RADII R AND R_1.

Fig. 1

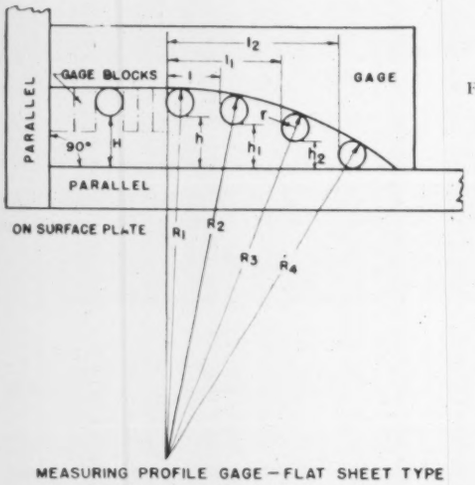


Fig. 2

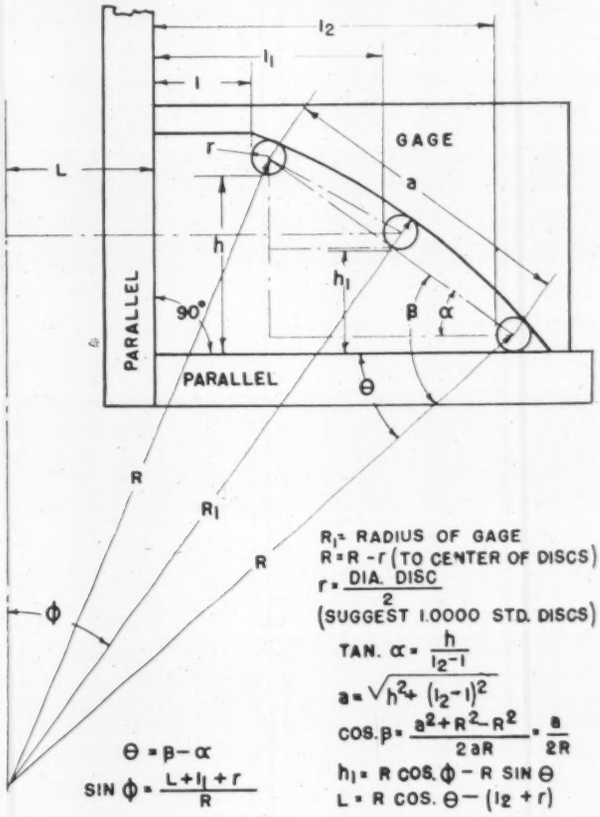


Fig. 3

MEASURING PROFILE GAGE – FLAT SHEET TYPE

r = RADIUS OF MEASURING DISC. (SUGGEST 1.0000 DIA STD.)
MEASUREMENTS H, h, h_1, h_2,
l, l_1, l_2 FOUND WITH PRECISION GAGE BLOCKS.

$R_1 = \frac{(2r)^2+4(H-h)^2}{8(H-h)} + r$

$R_2 = \frac{(2(l+r))^2+4(H-h_1)^2}{8(H-h_1)} + r$

$R_3 = \frac{(2(h+r))^2+4(H-h_2)^2}{8(H-h_2)} + r$

$R_4 = \frac{(2(l_2+r))^2+4H^2}{8H} + r$

IF GAGE IS CORRECT ALL R_3 WILL BE ALIKE

CHAPTER VII
PROFILE DETERMINATIONS

Two types of gages provide inspection control for all profile determinations—the profile template and full contour. Occasionally when the volume of production justifies the cost of the equipment, an optical comparator with an appropriate fixture is used in place of a template but, as yet, it is relatively unimportant as a gaging device.

By far the most widely used gage for profile determinations is the template. This type is one of the most familiar to the layman because screw pitch gages, center gages and radius gages are types of profile gages. This type is almost invariably used when the surface being inspected is not a mating surface. Examples, the ogive of a shell, the boattail, etc. The template is also used at times when the surface is mating. Rounds and fillets are almost always inspected with a template even though the surfaces are mating.

The profile template gage determines the conformity of surface contour *along a particular line*. This is essentially a two-dimensional inspection. By inspecting at a representative number of positions, the general conformity of the entire surface is established. Profile gages are made to basic dimensions. Seldom if ever is a profile gage designed as a "not go," although it would be possible in the case of a simple radius gage. A check gage is usually provided with a profile template since actual measurement of a template is often quite difficult.

R_1 = RADIUS OF GAGE
$R = R_1 - r$ (TO CENTER OF DISCS)
$r = \frac{\text{DIA. DISC}}{2}$
(SUGGEST 1.0000 STD. DISCS)

TAN. $\alpha = \frac{h}{l_2-l}$

$a = \sqrt{h^2+(l_2-l)^2}$

COS. $\beta = \frac{a^2+R^2-R_1^2}{2aR} = \frac{a}{2R}$

$h_1 = R \cos \phi - R \sin \theta$

$L = R \cos \theta - (l_2 + r)$

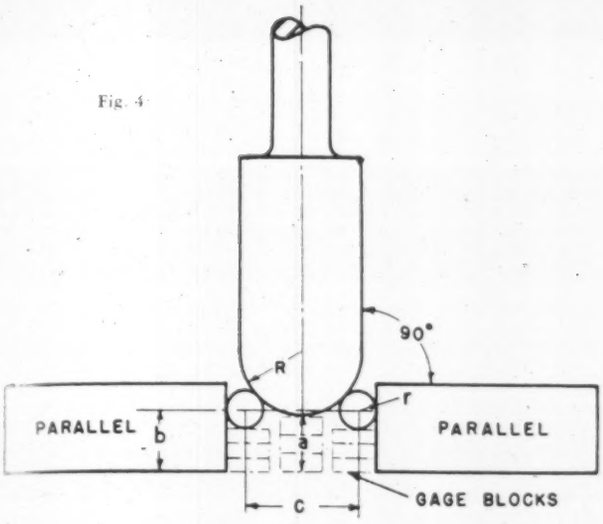
$\theta = \beta - \alpha$

SIN $\phi = \frac{L+l_1+r}{R}$

MEASURING PROFILE GAGE – FLAT SHEET TYPE WITH RADIUS STRUCK FROM POINT AWAY FROM GAGE

ANY NUMBER OF MEASUREMENTS MAY BE TAKEN USING THE ABOVE FORMULAS

Fig. 4



MEASURING PROFILE PLUG GAGE WITH ROUNDED END

R = RADIUS ON GAGE
r = RADIUS OF ROLL

$$R = \frac{c^2 + 4(b+r-a)}{8(b+r-a)} - r$$

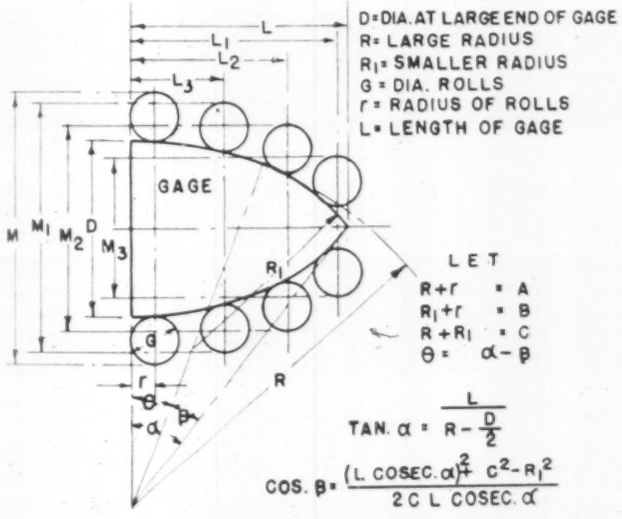
Full Contour Gages*

Full contour gages include profile plugs, receiver, and chamber gages. These gages perform essentially a three dimensional inspection of the component part. They are employed when the surface parts to be inspected are intended to mate with the surfaces of other parts. An entire surface is inspected at one time. As in the case of the template, a "go" gage only is used and a check piece is supplied to ascertain that the gage is correct. The gage shown in Fig. 1 is being used to inspect a die employed in manufacture of a shell casing.

Inspection

Inspection of profile gages presents some of the most engrossing problems in gage inspection. In general the problem will be one mathematical nature. Inspection will

*Not Standard Army Nomenclature



D = DIA. AT LARGE END OF GAGE
R = LARGE RADIUS
R_1 = SMALLER RADIUS
G = DIA. ROLLS
r = RADIUS OF ROLLS
L = LENGTH OF GAGE

LET
R + r = A
R_1 + r = B
R + R_1 = C
θ = α − β

$$\text{TAN. } \alpha = \frac{L}{R - \frac{D}{2}}$$

$$\text{COS. } \beta = \frac{(L \text{ COSEC. } \alpha)^2 + C^2 - R_1^2}{2\,C\,L \text{ COSEC. } \alpha}$$

THEN

$$M = D + 2G - 2\left(A - \sqrt{A^2 - r^2}\right)$$

$$M_1 = D + 2G - 2\left(A - \sqrt{A^2 - L_3^2}\right)$$

BE SURE L_3 IS NOT BEYOND POINT OF TANGENCY OF R AND R_1

$$M_2 = D + 2G - 2\left[A - \left(\sqrt{B^2 - (L_2 - C \text{ SIN. } \theta)^2} + C \text{ COS. } \theta\right)\right]$$

BE SURE L_2 IS BEYOND POINT OF TANGENCY OF R AND R_1

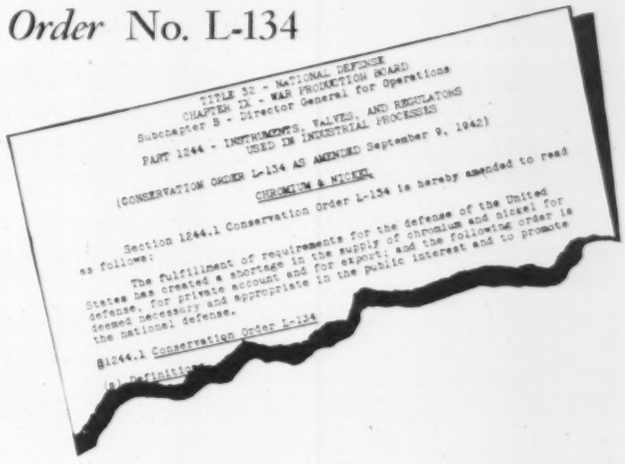
$$M_3 = D + 2G - 2\left[A - \left(\sqrt{B^2 - (L_1 - C \text{ SIN. } \theta)^2} + C \text{ COS. } \theta\right)\right]$$

MEASURING BULLET PROFILE CHECK GAGE

Fig. 5

How to **CONSERVE** *Essential* **INSTRUMENT MATERIALS**

in compliance with WPB *Conservation Order* No. L-134


TITLE 32 - NATIONAL DEFENSE
CHAPTER IX - WAR PRODUCTION BOARD
Subchapter B - Director General for Operations
PART 1244 - INSTRUMENTS, VALVES, AND REGULATORS USED IN INDUSTRIAL PROCESSES
(CONSERVATION ORDER L-134 AS AMENDED September 9, 1942)
CHROMIUM & NICKEL
Section 1244.1 Conservation Order L-134 is hereby amended to read as follows:
The fulfillment of requirements for the defense of the United States has created a shortage in the supply of chromium and nickel for defense, for private account and for export; and the following order is deemed necessary and appropriate in the public interest and to promote the national defense.
§1244.1 Conservation Order L-134

Many valuable solutions to problems arising from the new WPB Conservation Order L-134, which drastically limits the use of various materials for thermocouples, lead wire, thermometer bulbs, protecting tubes, etc., are given in the recently published Wheelco Supplement to Thermocouple Bulletin S2-3. The Supplement S2-3 is the result of an extensive analysis of the WPB Order L-134 by Wheelco Engineers and is published for the benefit of those who will be affected by this order. The Supplement also contains a partial summary of the L-134 Order; the complete L-134 Order as amended September 9, 1942, additions and revisions applying to various items in the Wheelco S2-3 Bulletin and a complete list of Wheelco Sales and Service Engineers who can help you with your instrument problems.

Write for your FREE copy of Supplement to Bulletin S2-3 and the issue of Wheelco Comments which deals with Thermocouple construction and maintenance.

Also request copy of Bulletin S2-3 if you do not have a copy.

Wheelco Instruments Co.
833 W. Harrison Street Chicago, Illinois

Originator of "Electronic Principle" Temperature Controls

PRECISION
INSTRUMENTS FOR INDUSTRY
Mercurial Vacuum Gauges
PRECISION THERMOMETER
AND INSTRUMENT COMPANY
PHILADELPHIA

automatic ruling of graduations on Linear Scales with the
GAERTNER

M 1310

Precision-Production
LINEAR DIVIDING MACHINE

Capacity: 25 inches Accuracy: ±.0001 inch
Speed: 10 to 45 lines per minute

Rulings can be made on flat, curved or beveled surfaces.

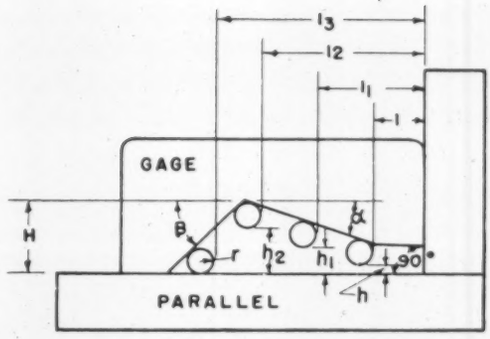
The spacing, width and length of lines can be adjusted, and various combinations of lines of different lengths can be ruled.

Temperature compensation from —70 to +110 degrees Centigrade is provided.

Both Metric and English scales can be ruled on this machine.

In order to save valuable time, please indicate type of work and accuracy required, in inquiry.

The GAERTNER SCIENTIFIC CORP.
1211 WRIGHTWOOD AVE., CHICAGO, U.S.A.



MEASURING ANGULAR PROFILE GAGE HAVING TWO ANGLES

r = RADIUS OF MEASURING ROLL
DIMENSIONS l, l_1, l_2, l_3, h, h_1, & h_2
FOUND WITH PRECISION BLOCKS

$$\text{TAN. } \alpha = \frac{h_2 - h}{l_2 - l}$$

$$\text{ALSO TAN. } \alpha = \frac{h_1 - h}{l_1 - l}$$

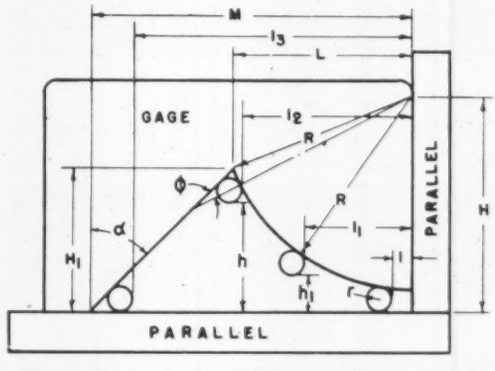
$$\text{TAN. } \beta = \frac{h_2}{l_3 - l_2}$$

$$\phi = \frac{180° - (\beta + \alpha)}{2}$$

$$H = \left(r \text{ COT. } \phi + r \text{ COT. } \frac{\beta}{2} + \frac{h_2}{\text{SIN. } \beta}\right) \text{SIN. } \beta$$

involve either surface plate or contour comparator work. If contour comparator is used, the inspection will usually require drawing of the profile to an enlarged scale. This is mounted on the screen of the comparator and the profile of the part is compared with this drawing.

Figs. 1 to 7 are drawings of typical surface plate set-ups for inspection of profile, template and full contour gages.



MEASURING PROFILE GAGE COMBINING ANGLE AND RADIUS

r = RADIUS OF MEASURING DISC
H = HEIGHT FROM WHICH RADIUS IS STRUCK
R = RADIUS ON GAGE:- SEE PLATE 47 FOR FORMULA
H_1 = HEIGHT OF INTERSECTION ANGLE & RADIUS
(ALL OTHER DIMENSIONS FOUND WITH PRECISION GAGE BLOCKS)

$$\text{TAN. } \alpha = \frac{l_3 - l_2}{h}$$

$$M = r \text{ COT. } \frac{90° - \alpha}{2} + r + l_3$$

$$r \text{ COT. } \frac{90° - \alpha}{2} + r + l_3 - H_1 \text{ TAN. } \alpha = L$$

$$\sqrt{(R+r)^2 - (l_2 + r)^2} = H - (h + r)$$

$$\sqrt{(R+r)^2 - (l_1 + r)^2} = H - (h_1 + r)$$

$$\sqrt{(R+r)^2 - (l+r)^2} = H - r$$

$$\sqrt{R^2 - (H - H_1)^2} = L$$

Fig

Calling All Readers with Ideas on Speeding War Work

(even old ideas—*especially* old ideas now producing results that should be better known)

IF you love America—and of course you do—it is your duty to do all you can to help America's mighty war industry grow mightier . . . fast! True, you are already going all out on your own job: at every month's end, you know you've done a good month's work to axe the Axis. (You've probably done what was two months' work before Pearl Harbor!) But perhaps you can make a suggestion that will save thousands of work-months. Yes, you, the typical reader: most useful suggestions don't come from a few geniuses but from the many wide-awake workers—each alert to see some "tremendous trifle" that had previously escaped notice. Especially is this true now. Especially is this true with regard to the use of instruments. And that's where you shine! One big bottleneck is that millions of inspectors and testers still have to rely on their hands, their eyes, their judgment subject to fatigue. Yes, here in America, where automatic gadgets have been invented, each doing the work of twenty or two hundred humans and doing it better! The pity of it is that there is no need for this bottleneck—because every type of test or determination is being done automatically somewhere. The few basic inventions have all been made; what's needed is ten thousand adaptations or applications—such as you have in mind right now . . . or such as you have already installed. (Don't be too modest: that "unimportant" automatic method over in the corner of the second floor of Building R-73 may not have been brought to the attention of the thousands who should know about it.) And there are some other bottlenecks in production that can be eliminated by the use of automatic instruments.

NOTE—In lots of places the inspectors and the management are so proud of "doing it in half the former time" that they can't imagine any further improvement *(but it could be done in one-hundredth the former time)*. In some cases there is a belief that the Army or Navy "wants it done just that way" *(but the spirit of AAN specs is results, not methods, and the higher officers want faster methods—provided that quality is not impaired but bettered)*. In many instances the only ban on automaticity is that the product to be tested or measured or controlled automatically or continuously is "different" *(but the instrumental function to be performed is exactly the same!)*.

YOU ARE INVITED, therefore, to send in your suggestion (or suggestions) for publication in the big January Special Issue of *Instruments*. The rules are simple:

1. Everyone is invited.

(On some previous occasions we excluded persons in the employ of instrument companies. Not this time! If you have worked out a new labor-saving application of any device, don't hold back because you happen to be selling that device. If one of your customers has worked it out, have him write it up; and if he is too busy or too modest, write it up for him.)

2. Contribution should be typewritten, double-space, on one side of $8\frac{1}{2} \times 11$ (or $8 \times 10\frac{1}{2}$) paper. Name and address of author typed at top of first page; name at top of other pages.

3. Diagrams should be in black ink on white paper (or tracing cloth or paper). No blueprints. Name and address of author on each diagram. *Good* photographs will be accepted.

4. Each contribution to describe the solution of ONE specific problem. Each author, however, may send as many as he wishes.

4a. Cash paid for descriptions published. See page 513.

5. Be brief, but don't omit descriptive details.

(If you describe the continuous automatic measurement of something usually measured intermittently by hand, don't write a book about the theory of automatic continuous measurements. On the other hand, don't send in something like this: "We have an automatic tester for length, weight, hardness and profile of A-1 cores that replaces twelve girls." That is too brief!)

6. A solution need not be an instrument: it can be a fixture, a conveyor, or any set-up that *makes possible or practicable** the use of an automatic instrument.

7. Write it up TODAY then put it away; a few days later, read it with a fresh mind and add any essentials you might have overlooked. All contributions must be on your editor's desk in Pittsburgh by DECEMBER 31.

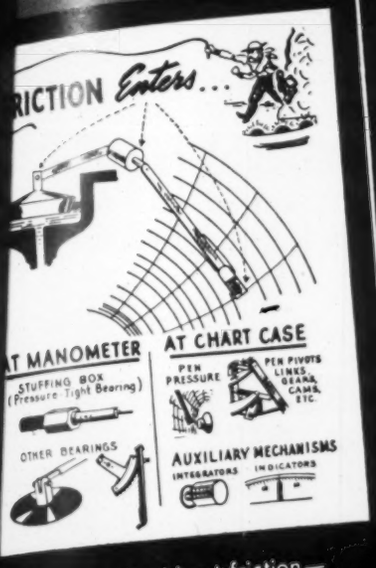
NOTE Postponed Closing Date

8. Owing to the large volume of mail received at this office, it is essential that all articles written in response to this invitation be addressed to: **War Work Speed-up Editor, The Instruments Publishing Co., 1117 Wolfendale St., Pittsburgh, Pa.**

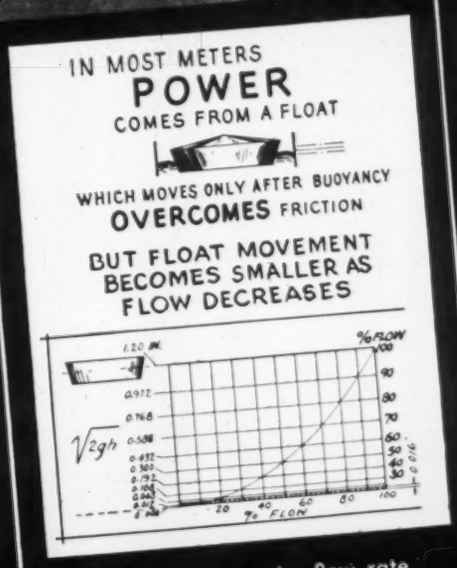
*For years I've been advocating the full-automatic or conveyorized inspection of artillery ammunition but always was told that although it is **possible** it is **impracticable** because moving heavy projectiles (above .50 cal.) wear down fixed gaging anvils or vees in hours or even minutes; because the elaborate hydraulic mechanisms for speedily shifting and then gently lowering the shells would take too many man-years to design, develop and test; and because they would require more man-years to manufacture in adequate ranges of sizes and models than would be saved. I was told that a typical installation would cost $25,000. Well, I'd like to see what **you** can do with shock absorbers now available by the millions in auto graveyards, plus a simple gravity-roll feed: maybe your installation (exclusive of the automatic electric or pneumatic gage and relay for tripping rejects) would cost nearer $25 than $25,000.—M. F. BEHAR, Editor, Instruments.

Gauging Flow Mete
Suppose you had the time to set up an ideal specification for a flow me
Naturally your first consideration would be accuracy. Here is a stand
for gauging meter accuracy. This standard is the ratio of power to fric
Let's Consider an
IDEAL FLOW METER
We would look for 4 POINTS
HIGH ACCURACY
LOW MAINTENANCE,
READABILITY, and
ADAPTABILITY to VARYING CONDITIONS
1. Accuracy is the No. 1 consideration.
MOST METERS MEASURE FLOW THRU THE VELOCITY HEAD
Produced by
ACCURACY DEPENDS ON HOW WELL THIS U HEAD IS TRANSLATED TO THE
and
2. Accuracy depends on what's between the orifice and the chart.
IN ALL METERS...
FRICTION MUST BE OVERCOME
POWER MUST BE DELIVERED TO PEN
HIGH ACCURACY = POWER / FRICTION
3. Here then is the basic standard ... POWER / Friction
The COCHRANE METER
... Approaches This Ideal
Lets See How!
7. Well, let's see how we do it.
COCHRANE Friction Free FLOW METER
STARTS with a FRICTIONLESS TRANSMITTER
FRICTIONLESS FLOAT IS PILOT FOR
% FLOW
ENDS with HIGH and EQUAL POWER AT PEN THRUOUT SCALE
8. Exactly as the ideal requires, the motor supplies high power from 0-100% ...
COCHRANE Friction Free FLOW METER
Gets its accuracy from BASIC DESIGN
MEASURING CIRCUIT
RELIEVED OF ALL WORK
FRICTION FREE Transmitter
SENSITIVE DETECTOR (Galvanometer)
POWERFUL Balancing & Recording Mechanism
In Accordance with
The NULL Method
UNIVERSALLY RECOGNIZED AS THE METHOD OF PRECISION MEASUREM
9. because in this NULL syste the circuit does no work.

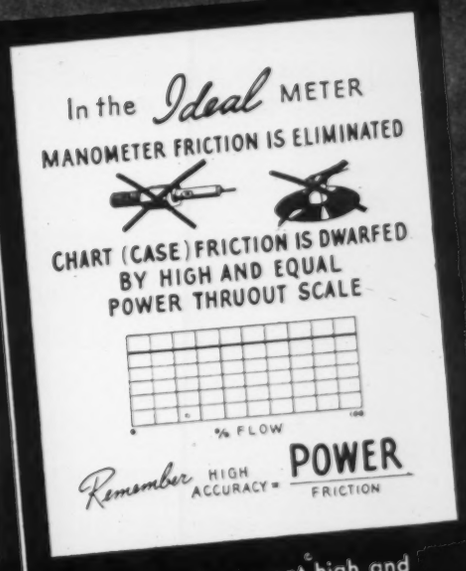
Accuracy



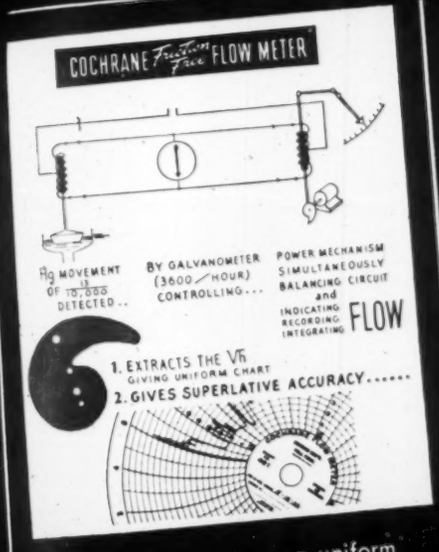
4. No meter is without friction—and some have considerable.



5. And the lower the flow rate the smaller the power ($\sqrt{2gh}$)


In the Ideal METER
MANOMETER FRICTION IS ELIMINATED
CHART (CASE) FRICTION IS DWARFED BY HIGH AND EQUAL POWER THRUOUT SCALE
% FLOW
Remember HIGH ACCURACY = POWER / FRICTION

6. Note well we want high and equal power from 0 to 100% flow.


COCHRANE Friction Free FLOW METER
BY GALVANOMETER (3600/HOUR) CONTROLLING...
POWER MECHANISM SIMULTANEOUSLY BALANCING CIRCUIT and INDICATING RECORDING INTEGRATING
FLOW
1. EXTRACTS THE $\sqrt{h}$ GIVING UNIFORM CHART
2. GIVES SUPERLATIVE ACCURACY.....

10. The cam produces a uniform chart AND superlative accuracy because . . .

AND AS VISIBLE PROOF
EACH Cam Shaped to exactly record water column differential thruout scale
Note: ENTIRE Absence of Friction Lag 10 to 100%
COCHRANE
Flow Metering

11. each cam is INDIVIDUALLY calibrated at 10 test points as shown by the final record chart.

12. Ask us to tell you the complete story covering also Maintenance, Readability, and Adaptability.

COCHRANE

3100 N. 17th STREET PHILADELPHIA, PA.

"DANGER SPOTTERS"

A RED LIGHT winked out of the darkness! The pilot snapped to attention and checked his instruments for trouble . . . port engine fuel pressure dangerously low!

Instantly, he worked with the emergency hand wobble-pump, brought the pressure back to normal—and managed to keep it there until he reached destination.

The above incident, which actually happened over the mid-Atlantic on the ferry trip of a bomber bound for Britain, illustrates the importance of Pressure Warning Units to the pilot.

As you know, these little "danger spotters," weighing less than 6 ounces, free his eyes from constant instrument checking—for rest, for reconnaissance or combat operations . . . yet give instant warning of falling fuel or oil pressure in any engine before it becomes serious.

The Pressure Warning Unit is one of many devices and precision instruments which Kollsman makes for the Army and Navy, instruments that make our military aircraft safer and more efficient in flight.

KOLLSMAN
AIRCRAFT INSTRUMENTS
Product of
SQUARE D COMPANY
ELMHURST, NEW YORK • GLENDALE, CALIF.

APPLICATIONS OPERATING PRINCIPLES INSTALLATION MAINTENANCE

Aviation Instruments

Navigation Automatic-piloting Power plant Automatic-landing Aerological
Communication Flight-testing Production Instrument-testing

Vol. I, No. 7 GUEST EDITOR: W. J. WATKINS December 1942

THE INSTRUMENT TECHNICIAN

His Growing Importance in All Divisions of Aviation

Editorial by **W. J. WATKINS**, *Guest Editor*,
Chief Instructor, American School of Aircraft Instruments, Glendale, Calif.

Who He Is and What He Does

THE instrument technician has been called "the man behind the man at the controls." This is no mere romantic description. It is a fact that the pilot's mind can be at ease about the safe, efficient operation of the ship. The pilot knows that the instruments are telling the exact truth. He knows that they have been pronounced in perfect operating condition by an expert—the instrument technician.

Behind the man at the controls there are, in fact, many instrument men. They have first carried out the design, precision manufacture, and scientific testing of instruments, then installed them, and again checked the instruments and pronounced them ready for their first service in the air—and later inspected, repaired, and overhauled these vital aids to flight.

William J. Watkins is a leading national authority on training in aircraft instrument maintenance who pioneered the preparation of aircraft instrument textbooks and the development of shop training methods. He came to the field of aircraft instruments with a broad background of mechanical, electrical and technical experience. When he first became associated with Herbert W. Hartley in the operation of the American School of Aircraft Instruments, the field of instruction in instrument maintenance was in its early stages. Instrument work was commonplace in airline maintenance operations, of course, but the importance of instruments was increasing by leaps and bounds and there were comparatively few men who possessed organized practical training. Mr. Watkins attacked this problem and found his first hurdle to be the lack of text material suitable for instructing men who possessed little or no previous knowledge of aircraft instruments. He gathered together all available material from governmental sources and instrument manufacturers and carried out extensive personal research. The result was a complete set of lesson texts covering all phases of maintenance of instruments, replete with illustrations and diagrams explaining the text and picturing specific operations. This material has undergone constant revision and amplification in line with progress in aircraft instrumentation. Equally important has been Mr. Watkins' development of shop training equipment and methods. Guided by practically no precedents, he has succeeded in duplicating actual instrument maintenance conditions, equipment and procedure as existing in actual instrument shops, such as those of the airlines. He has been responsible for a large number of distinct advances in the development of instrument testing devices. Many instrument mechanics and technicians in all branches of aviation have been trained under his direction, so that the benefits of his work in this field have become widespread in the industry.

Instrument Progress Revolves Around the Instrument Man

The instrument technician is in the midst of instrument development and improvement. If with an instrument manufacturer, he is at the very starting point. If with an aircraft builder, he can observe the suitability of design for quick installation and efficient operation. If in an airline instrument maintenance department, or in Civil Service at an Army or Navy aircraft maintenance depot, he grows intimately familiar with construction and operation.

The instrument technician is not only of ever-mounting importance because the continued, and even greater, safety of flying depend on his expert craftsmanship, but also because he is the man best qualified to point out and create improvements in instruments. This is both a stirring challenge and a magnificent opportunity for the man considering entering instrument work.

Now Even More Important in Military Aviation

Playing a part in peace-time progress is still ahead for the instrument man—but his most vital role NOW is the great contribution he makes to our success in the air. On his highly specialized skill and knowledge depends the effective operation of all our fighting planes, as well as the swift return to the air of many. Whether employed by the instrument manufacturer, aircraft builder, in Civil Service, or in direct Army or Navy aircraft maintenance, he is on our first line of defense.

The Past Foretells the Future

Throughout the history of aviation there has been an ever-swelling crescendo of the cry "More planes, more planes." The *fun* of flying has steadily increased the demand for private planes, while the *business* of flying has required ever-mounting numbers of transport planes. At the same time the number of hours in the air, for each pilot and for each plane, has increased tremendously.

Meanwhile the *necessity* of flight in military operations created huge air forces. Production of fighting planes for friendly nations, and for our own preparedness program, reached huge proportions which, under the dictates of actual conflict, were quickly surpassed. For wartime combat, for peace-time preparedness, our leaders plan for our country "an air force second to none."

Today's aviation statistics dwarf to insignificance the figures of only a decade and less ago. Even so, authorities agree that the airplane is in the stage of public use similar to the automobile's early days . . . that the world will be a vast network of airlanes over which will travel virtual flying freight and passenger trains . . . that military power

(Continued on Page 524)

PRIMARY Pressure Instrument Shop

ADVANCED Pressure Instrument Shop

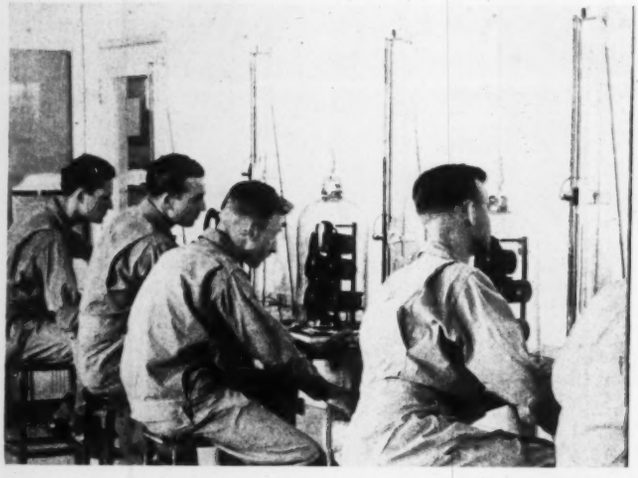
Two of the CIVILIAN Shops, American School of Aircraft Instruments

Training Military and Civilian Personnel as Aircraft Instrument Technicians

By W. J. WATKINS

Chief Instructor, American School of Aircraft Instruments

FOR several years before December 7, 1941, American School of Aircraft Instruments had been training civilians for placement in airlines, Civil Service shops and private instrument repair shops. During these years, American School of Aircraft Instruments had grown from a small school to the largest specialist school on aircraft instruments in the United States. In fact, for many years, it was the only instrument specialist school in the country.



Enlisted Men Testing Pressure Instruments After Overhaul, U. S. Army Air Forces Technical Training Detachment, A.S.A.I.

During those years of development, there were many problems to be solved, such as lack of text material, course of study, etc. As is always the case in pioneering, we had to solve these problems for ourselves. By compiling all available material from the manufacturers and augmenting it with theoretical explanations, as well as by securing first-hand information of service problems from the airlines, we were able to create a satisfactory text. By trial and error with various systems of training, we finally arrived at a course of study which proved satisfactory for the training of instrument mechanics for the airlines and Civil Service bases.

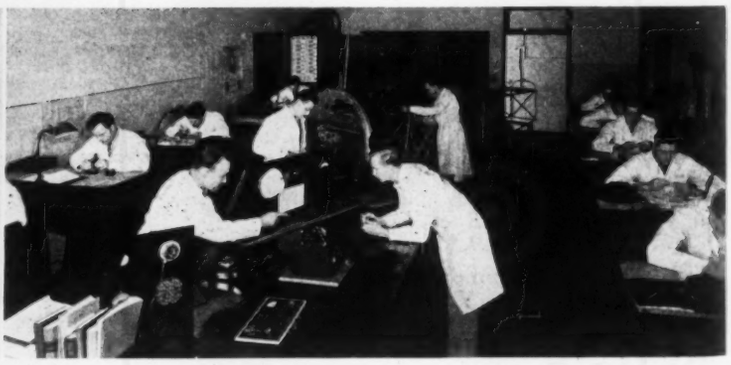
This course of training covers the complete field of aircraft instruments, both in theory and shop practice. The student progresses through the primary pressure instrument shop, the advanced pressure instrument shop, the electrical instrument shop and the gyro instrument shop.

It takes six months to complete this course of study, after which a student is fully qualified to enter the field of aircraft instruments. In fact, this six-month course is accepted in lieu of two year of experience in applying for the position of Junior Instrument Mechanic positions on Civil Service.

After December 7, 1941, the Army became interested in the training of enlisted men in this specialized work. Upon checking with airlines, Civil Service bases and instrument manufacturers, it was decided that American School of Aircraft Instruments was the logical place for such training. However, it was their desire to have these men trained as specialists in only one phase of instrument work. This did not present any serious problem as we already had our

(Continued on Page 540)

Army Enlisted Men Testing Electrical Instruments After Overhaul.



A Corner of the Electrical Instrument Shop, Civilian Quarters.

Military and Civilian ELECTRICAL Instrument Training, A.S.A.I.

Overhaul Procedure—Pendulum Assembly of Horizon and Bank & Climb Unit

By ROBERT BEN KEES

Chief Civilian Gyro Instrument Instructor, American School of Aircraft Instruments

BECAUSE of lack of information on the overhaul of the pendulum assembly, gyro mechanics sometimes encounter trouble with this operation. After considerable experimenting, the following system of overhaul has been adapted as standard at the American School of Aircraft Instruments. If each step of this procedure is followed *with the utmost care*, it is possible for any mechanic to make a good overhaul job on the pendulum assembly.

1. After the pendulum assembly has been removed from the rotor housing, clean the assembly by washing it in naptha and dry under air pressure.

2. Next, clean the assembly in a bath of jeweler's rejuvenator, agitating the assembly and working each pair of vanes back and forth several times.

3. Wash the assembly in clean warm water until all traces of rejuvenator have been removed and dry thoroughly under clean low-pressure air.

4. Insert the pendulum gage T 20594 through the elongated hole below the high shaft with the recessed side facing the beveled edge of the vane. If the vanes are at their right setting, the pendulum gage will just pass the beveled side of the vane on the opposite side. (Note: It has been found desirable to have the fore and aft vanes open about 40% while the side vanes are 50% open.)

(Continued on Page 540)

Training in GYROSCOPIC instruments, A.S.A.I.

Top and Inset—U. S. Army Air Forces Technical Training Detachment. *Bottom*—Advanced department of civilian quarters.

Pressure Instrument Department, U. S. Army Air Forces Technical Training Command, American School of Aircraft Instruments.

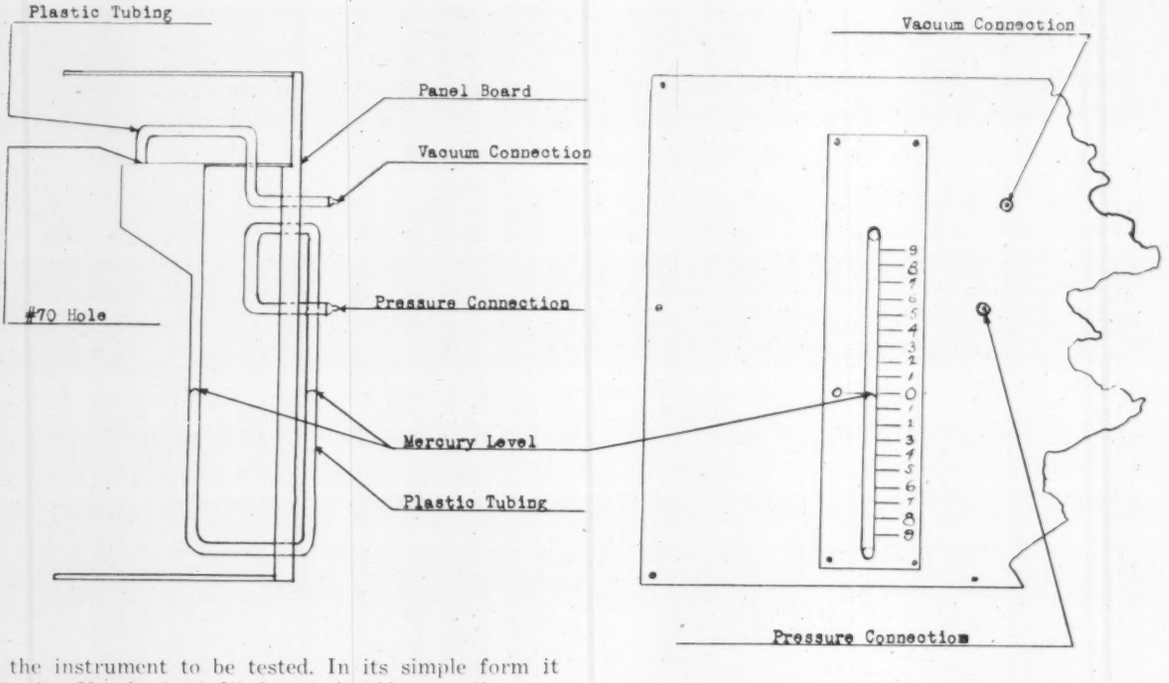
An Improved Manometer Built of Plastics

By JAMES STUART

Chief Army Instrument Instructor, American School of Aircraft Instruments

A NEW type of manometer has been designed for use in the Gyro shop at The American School of Aircraft Instruments. This new type of manometer is made entirely of plastics.

A manometer is an instrument to measure the differences in pressure from atmospheric; therefore one end of the manometer is open to atmospheric pressure and the other end to the instrument to be tested. In its simple form it consists of a U tube half filled with liquid, (usually mercury). On one leg of the U tube, a trap or surge chamber has been designed to prevent the loss of mercury. This surge chamber is an enlarged part of the U tube, with sufficient capacity to hold the total amount of mercury in the tube. If the pressure is considerably greater than atmospheric pressure, usually caused by a pinched line, this surge chamber will prevent the loss of mercury by allowing the mercury to enter the expanded portion of the U tube; therefore the pressure or vacuum will pass around the mercury.



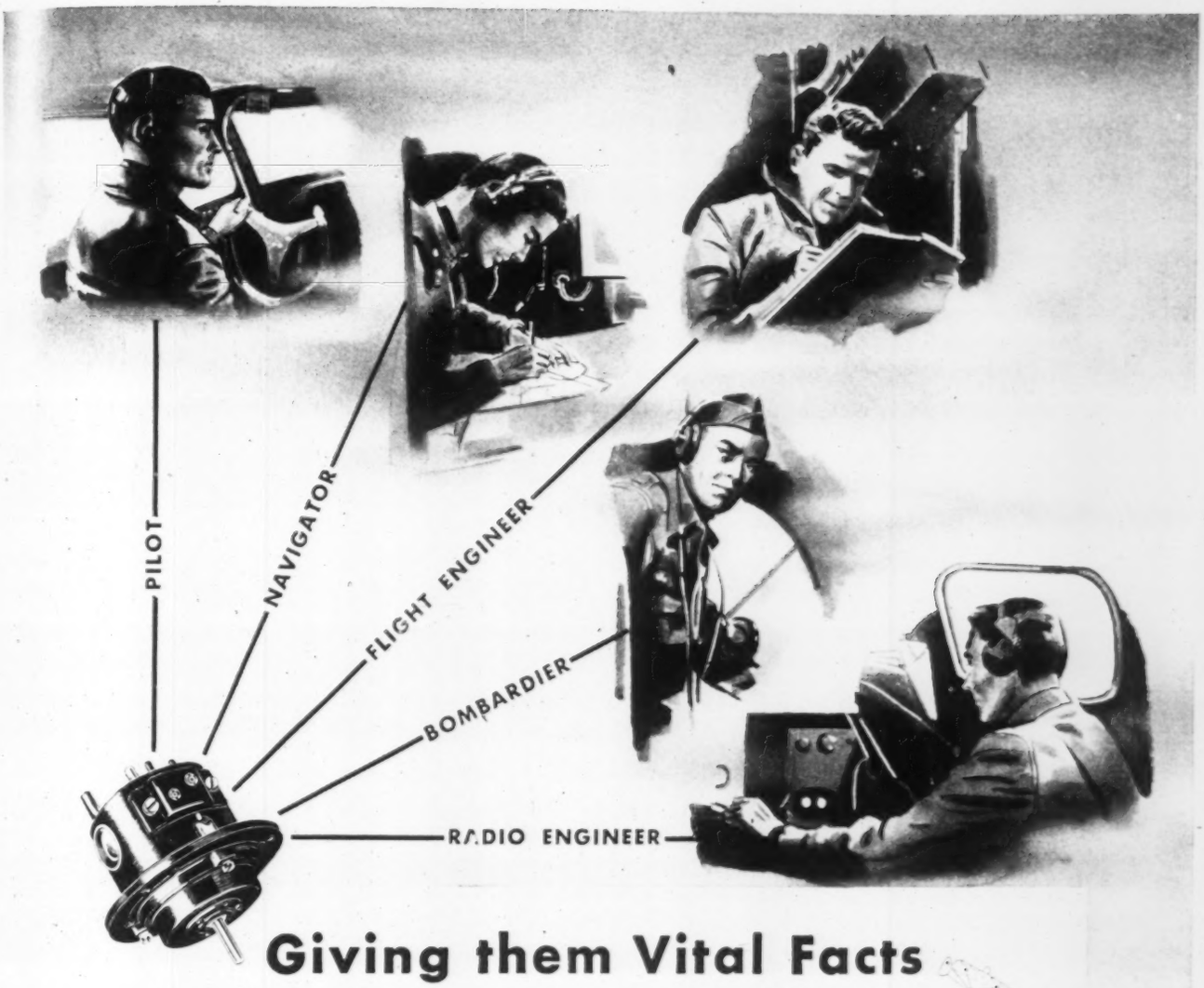
The surge chamber or trap is made of clear Lucite 1½" in diameter and 2" long. This is closed at both ends with Lucite sheeting cut to size. The bottom of the trap tapers toward the U tube; therefore the mercury will run back into the U tube. This trap is welded together with chloroform. On the top of the trap a connection is welded, with a No. 70 drill opening. In the vacuum manometer the hose leading to the instrument is connected here. In the pressure manometer the opposite leg of the U tube is connected to the instrument. The U tube is made of clear Tenite ½" in diameter and 24" long. This can be formed into the U shape by placing it in warm water and bending. The U tube is then welded to the trap with chloroform. Only one leg of the manometer is seen by the mechanic, the other being behind the panel as the diagram shows. The scale is made of Lucite sheeting cut to size and graduated in inches of mercury.

The Instrument Technician—His Growing Importance

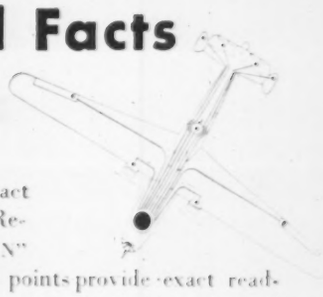
(Continued from Page 521)

will consist almost solely of mammoth air forces. Undoubtedly, these countless and mounting thousands of planes will proportionately multiply the number of instruments in service. More than that—because *more* instruments per plane will be required for the bigger aircraft of the future, for regularly scheduled flight regardless of weather conditions, for longer flights, and because of more instrument flying by private flyers.

It is not only more planes and more instruments, but also greater use of all types of aircraft, that makes instrument maintenance an evergrowing, *permanent* division of America's Greater Aviation.



Giving them Vital Facts by *Remote Indication*



SWIFT, intelligent action on the part of a combat plane's crew must be based on facts accurately determined and quickly conveyed. Obtaining and transmitting such information...from many vital points throughout the plane...is the important job entrusted to the "PIONEER AUTOSYN" System.

Incorporated in precision instruments in tail, flaps, landing gear, engines, fuel tanks and other parts of the plane, are "PIONEER" Transmitter "AUTOSYN" units like the one illustrated. These small, ingenious mechanisms transmit exact measurements. Receiving "AUTOSYN" units at desired points provide exact readings. The whole system operates through low voltage wiring, eliminates long shafts and heavy, cumbersome tubing carrying dangerous liquids or fumes.

"PIONEER" Flight, Navigation and Engine Instruments are designed and built by men and women whose single aim is to give our flyers the finest equipment obtainable.

Precision aircraft instruments of the Pioneer Instrument Division are important members of "The Invisible Crew," which includes the equipment and controls built by 25 Bendix plants from coast to coast and serving with our fighting crews on every front.

THE INVISIBLE CREW
Precision Equipment by Bendix
AVIATION CORPORATION

PIONEER INSTRUMENT DIVISION

Electrical Instrument Department, U. S. Army Air Forces Technical Training Command, American School of Aircraft Instruments

An Electrical Instrument Test Panel

By HAROLD L. HAMM

Chief Instructor of Army Electrical Instrument Department, American School of Aircraft Instruments

IN these days of shortages, priorities and poor shipping conditions, many an instrument repair man has had to tax his ingenuity to the utmost. In order to have adequate test equipment, single test instruments must be calibrated to cover many ranges. These must also be accurate and readily adaptable to a quick change from one aircraft instrument to another.

In order to meet these demands, the instrument described was developed in our electrical shop. It has replaced several pieces of more costly and elaborate test equipment, and has been found to do the job just as quickly and efficiently.

This instrument is a test panel measuring microamps, milliamps and millivolts, obtaining its power from a 12-volt storage battery. This power is uniformly controlled by two potentiometers, one for voltage and the other for current. The potentiometers are made of a high-quality wire giving smooth even control throughout the range.

The test panel is simple in construction, the materials needed being one dural or aluminum panel, one #301 type Weston instrument having a range of 200 microamps, and an internal resistance of 53 ohms. Resistors of manganin wire are used because of their extremely low temperature coefficient of less than 0.00001 ohms. They are wound on Bakelite spools on the back of the panel. Any good two-bank selector switch of twelve contacts may be used, being sure that it is of rugged construction, with good wiping contacts of low resistance.

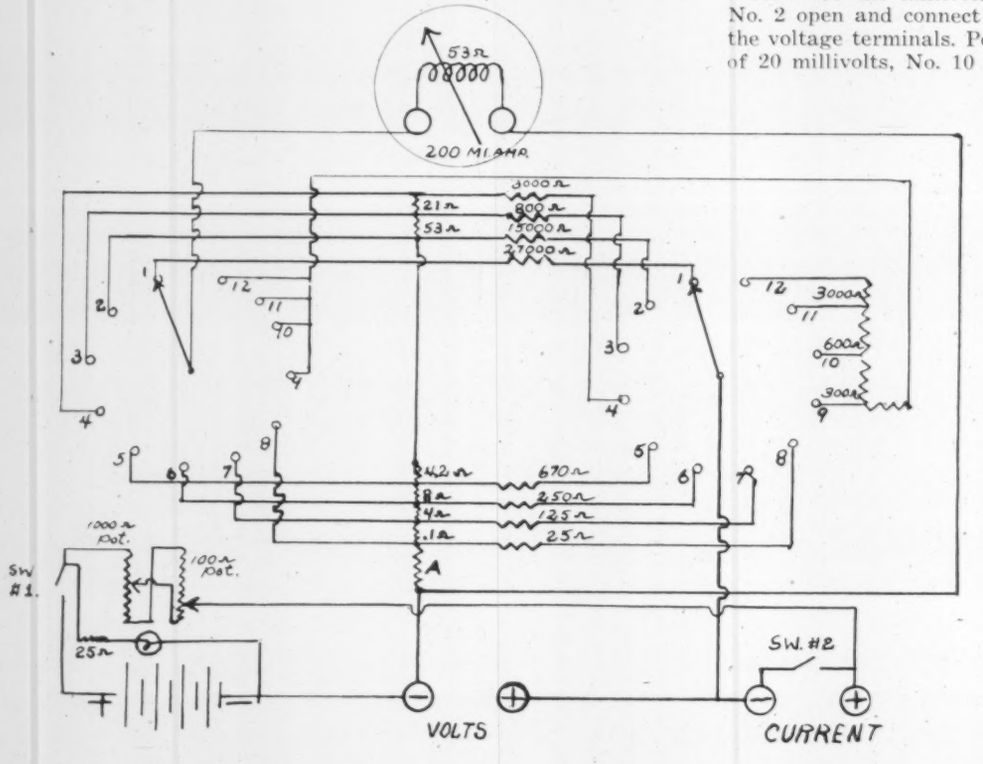
The use of separate pin jack contacts for the current and voltage outputs requires the use of only one toggle switch to change from current to voltage, using this switch to short out the current terminals when only the millivolt contacts are being used.

A unique feature of this panel is the use of voltage-limiting resistors in series with the microammeter to prevent high voltage from being accidentally connected across the contacts of the microammeter when the selector switch is on one of the low-current ranges. The twelve ranges, as given on the selector switch, are brought into use in most cases by an even multiple of the original range of 200 microamps. Position number 1 is a direct connection from the current terminals to the terminals of the microammeter itself. With each change of the selector switch, either shunts or multiplying resistors are brought into the circuit covering the following ranges: No. 1, 200 microamps; No. 2, 400 microamps; No. 3, 800 microamps; No. 4, 2 milliamps; No. 5, 8 milliamps; No. 6, 20 milliamps; No. 7, 80 milliamps; No. 8, 100 milliamps completing the current ranges.

Now for the millivolt ranges: Throw the toggle switch No. 2 open and connect the instrument to be tested across the voltage terminals. Position No. 9 gives us the low range of 20 millivolts, No. 10 cuts in another multiplier to bring the range up to 80 millivolts. Position No. 11, 200 millivolts and the last position, No. 12, 400 millivolts.

To make the check of any sensitive instrument, connect the terminals across the contacts corresponding to either a current or a potential type of indicator. Throw toggle switch No. 2 to a corresponding position, then with the voltage and current potentiometers turned to the off position, turn the toggle switch No. 1 to the power supply. Bring both voltage and current potentiometers to the on position until instrument to be tested reads full-scale, then make a note of the scale reading to determine the sensitivity of the instrument.

Resistor *A* in the test panel may be a small variable resistance under 5 ohms used to counteract any changes in the sensitivity of the indicator and may be adjusted accordingly.



Make accurate tests

of Delicate Precision Instruments

the AMCOIL way

KNOW IN ADVANCE how instruments will perform under service conditions. Amcoil Chambers test accurately and automatically under extremes of cold and heat. In addition to the mechanical refrigeration and dry ice models illustrated, there are Amcoil Test Chambers for other uses, including humidity and altitude testing.

Information on these types as well as further details on those shown here will be furnished on request. Address Dept. I-12

AMCOIL

Low and High Temperature Test Chamber Model RTC3

- Mechanical Refrigeration (Quick Pull Down)
- Range: −55°C. to +70°C. (−67°F. to +160°F.)
- Exterior: 50" wide x 41" high x 36" deep, Stand: 34" high
- Usable interior: 27" wide x 19" high x 26" deep
- Interior Content: 7.7 cu. ft.

AMCOIL

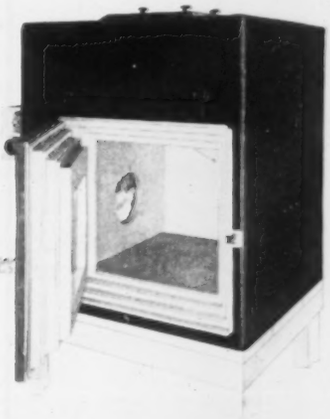
Low and High Temperature Test Chamber Model RTC1

- Mechanical Refrigeration (Quick Pull Down)
- Range: −55°C. to +70°C. (−67°F. to +160°F.)
- Exterior: 71" wide x 56½" high x 42" deep, Stand, 35¾" high
- Usable interior: 59" wide x 28½" high x 39" deep
- Interior Content: 28.7 cu. ft.

AMCOIL

Low and High Temperature Test Chamber Model RTC-1A

- Mechanical Refrigeration (Quick Pull Down)
- Range: −70°C. to +70°C. (−95°F. to +160°F.)
- Exterior: 71" wide x 56½" high x 42" deep
- Usable interior: 52" wide x 27½" high x 39" deep
- Interior Content: 25 cu. ft.



AMCOIL

Low and High Temperature Test Chamber Model MS0TC-1

- Dry Ice Refrigeration (Quick Pull Down)
- Range: −55°C. to +70°C. (−67°F. to +160°F.)
- Exterior: 40" wide x 43" high x 40" deep
- Usable interior: 21" wide x 21" high x 28" deep
- Interior Content: 7 cu. ft.

Our line is 100% converted to war-needed test cabinets

* AMCOIL *

AMERICAN COILS INC.

25-27 LEXINGTON STREET • NEWARK, N. J.

3130

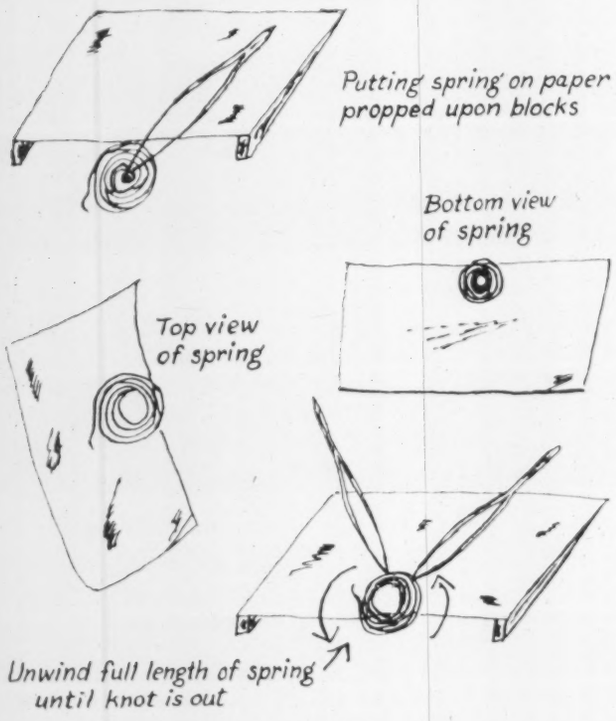
SHOP KINKS

Untangling Hairsprings

By OTTO THRESS
Chief Army Pressure Instrument Instructor, A.S.A.I.

HOW many times have you gnashed your teeth and torn your hair at the sight of a very delicate hairspring tied in knots? Relax, chum, here is a gag that really will keep you from growing old.

Avail yourself of a piece of paper about the thickness of jeweler's rice paper, placing the paper at such an angle as


Putting spring on paper propped upon blocks
Bottom view of spring
Top view of spring
Unwind full length of spring until knot is out

to have approximately one inch of one edge an inch or so above the desk surface.

Remove hairspring from staff and place hairspring with collet down over the inclined edge of the rice paper in such a manner that the paper will be between the collet and first spring coil.

Very gently, so as not to distort the spring, revolve that entire portion of the spring on the top of the rice paper so as to cause the hairspring to crawl round by round to the underside of the paper. Continue this procedure until the first knot is on the edge ready to go to the underside. Now, with two pairs of tweezers, hold the spring coil in front of the knot stationary, and feed the loose end through the knot the same as you would untie a knot in a piece of cord. By following this procedure, any number of knots may be removed without the least hairspring distortion.

Try it and see how rosy the hairspring world will look.

Electrical Instrument Service Kinks

By O. F. HURST
Chief Civilian Electrical Instrument Instructor, A.S.A.I.

1. SOCKET WRENCHES THAT FIT IN STARRETT SCREW DRIVERS

IN servicing electrical instruments one finds that there are a number of small size nuts on the various instruments and that socket wrenches to fit them are hard to get (some sizes are impossible to get). Our needs for these wrenches were so great at the American School of Aircraft Instruments that we decided to make our own. After experimenting with a number of ways to make them, we finally decided to use size 0.010" drill rod for the shank and Allen set screws for the socket. We used the Allen set screws in the following sizes: 0.050, 1/16, 5/64, 3/32, 1/8, 5/32, 3/16 and 1/4. This gave a good variety of sizes that proved to be well worth making.

The 0.015 drill fits in the Starrett screw drivers. Cut the drill rod in 2" lengths and turn down one end of drill rod

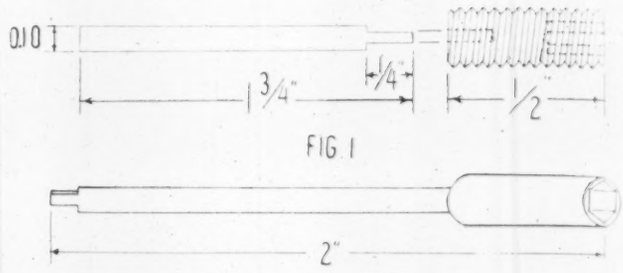


FIG. 1

in jeweler's lathe. See Fig. 1. Drill hole in Allen set screw to accommodate drill rod as also shown in Fig. 1.

Chuck drill rod in lathe, slip Allen set screw on rod, then bring tail stop up on lathe to hold the two firmly in place. After tinning the two with solder, sweat the two pieces together. We have found that solder will hold all the pressure that can be given when used in the Starrett screw drivers.

We found that the hexagons in the Allen set screws are not centered, so by centering in the lathe when soldering together, you get a well-centered socket wrench. With the set-up still in the lathe, use a cutting tool or a file on the smaller sizes and take the threads off the Allen screws to the point where no thread mark shows. As a final touch-up, use jeweler's rouge to polish.

2. JIG FOR MOVING COILS

Here is a simple and easy way to make jig to hold moving coils. This jig will accommodate all sizes.

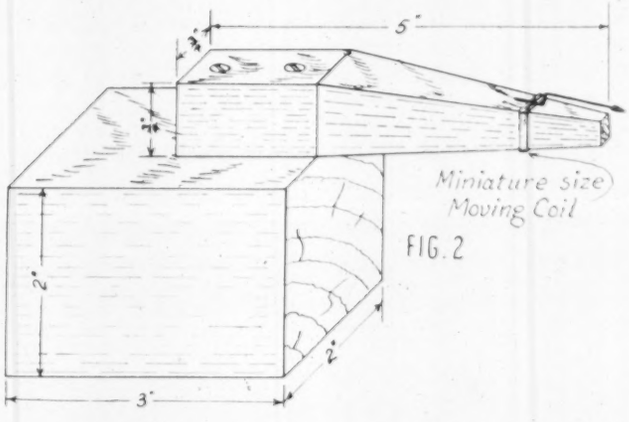


FIG. 2

Use a 2" × 2" piece of pine, 3" long for the base. (Fig. 2.) For the coil holder, use a 3/4" × 3/4" piece of pine, 5" long. Taper down to accommodate the smallest size moving coil that you are likely to encounter. Then screw down to base. Fig. 2.

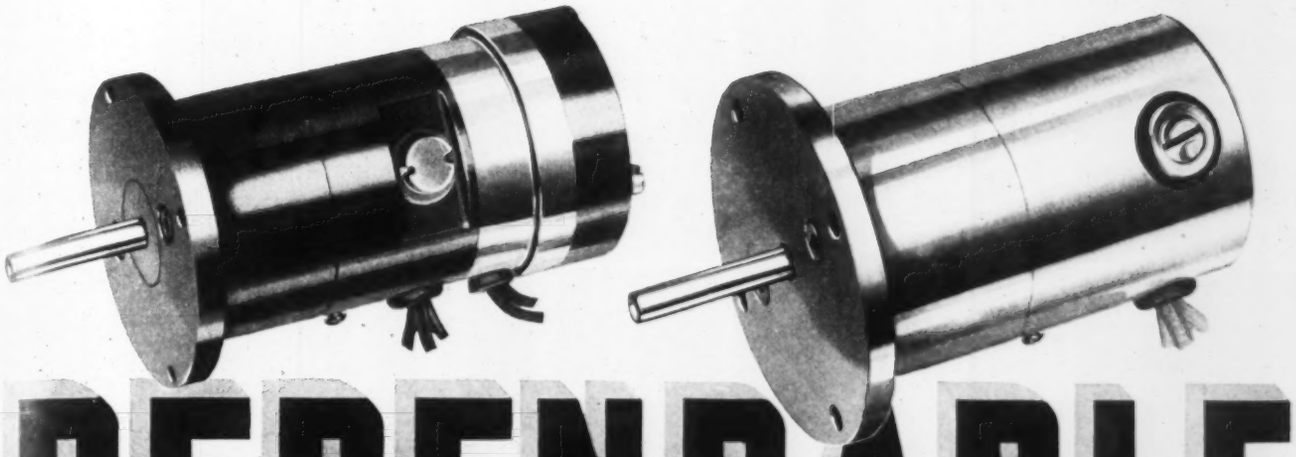
How to Drill 'em Smooth and Round

By CARROLL MOSER
Army Pressure Instrument Instructor, A.S.A.I.

MUCH difficulty is often experienced when working with metal, in drilling holes that are round and not three-cornered. Grooves in the walls are also hard to overcome.

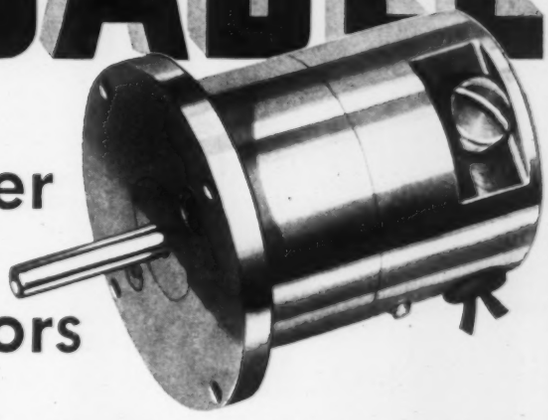
Good, true holes can be drilled best by chucking the object to be drilled in the lathe chuck or clamping it to a

(Continued on Page 540)



DEPENDABLE

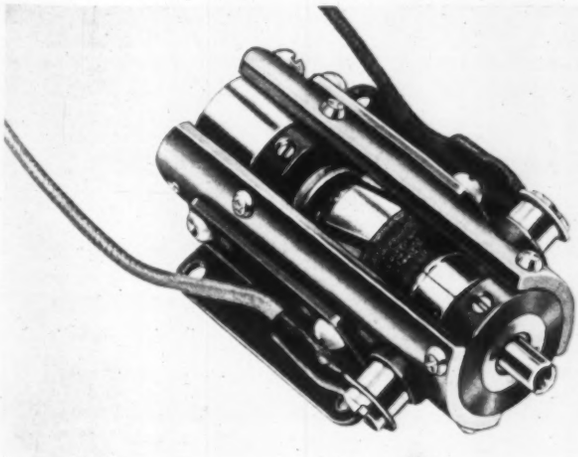
is the word that fits Oster



FRACTIONAL H.P. Electric Motors

It's the right word, because there is a solid foundation for Oster dependability. Fifteen years of manufacturing experience. Established standards of precision. A veteran labor force, accustomed to working together. A background of thorough engineering. A performance record (as original equipment on Oster appliances) that includes years of service for various departments of United States and foreign governments . . . All these are *facts* that back up your good judgment in selecting Oster. Remember Oster as a name worth remembering, in the fractional H. P. field. *John Oster Mfg. Co., of Ill., Genoa, Ill.*

M-5



¼ HP AND SMALLER

BAILEY METER
CONTROL SYSTEM

The Mark of

Effective Control

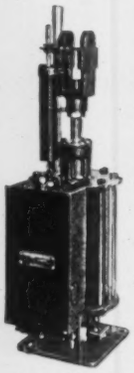
Process Control for sensitive, stable automatic control of temperature, pressure, liquid level, flow and other factors as applied to industrial processes. Responds to changes quickly, without overtravel or hunting. Ask for Bulletin No. 101.

Combustion Control that is simple but *complete* for providing economical operation of boilers of 200 h. p. and larger. Details in Bulletin No. 102.

Recorder-Controller

Boiler Meters for recording combustion conditions and guiding boiler operators. Described in Bulletin No. 44.

Multi-Pointer Gages for indicating factors such as draft, pressure, temperature and speed. These Gages are available with any number of pointers and any scale combination; in either the oil sealed bell or diaphragm construction.



Control Drive

Flow Meters for indicating, recording and integrating the flow of steam, water, sewage, air, gas and other fluids. Bulletins No. 39 and 300.

Recorders for pressure, temperature, drafts, liquid level and other factors.

G-3

BAILEY METER COMPANY

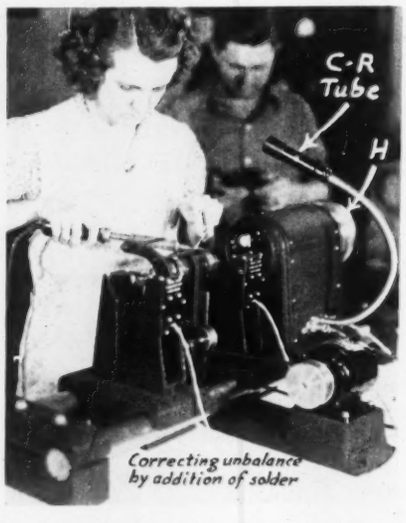
1041 Ivanhoe Rd., Cleveland, Ohio

The Month's NEW INSTRUMENTS

In this department we strive to report each month ALL the new devices for measurement, inspection, testing, metering and automatic control—in the form of concise technical descriptions. When writing to manufacturers directly, please mention this department as your source of information. Or write to Information Section, Instruments Publishing Company.

Balancing Machine for Mass Production Uses

New "Dynograph" is a precision dynamic balancing machine for determining and indicating both amount and position of unbalance in rotating parts, through a single reading of the trace on the screen of a cathode-ray tube (an inertialess electrical indicating device which responds instantly to voltages applied to its control plates). Control voltages for the cathode-ray tube are generated as a result of the rotation and vibration of the unbalanced part while spinning in light-weight free-floating bearings. Amount of unbalance is shown directly by height of trace on scale of cathode-ray tube. Position of unbalance is also

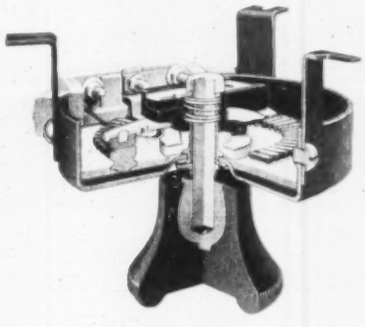


Correcting unbalance by addition of solder

shown by the trace, by indicating phase relation between the voltage produced by vibration and that produced by rotation. The control voltage due to rotation is produced by a special photoelectric generator which is "coupled" to the part being checked through the medium of a beam of light, no mechanical coupling being necessary. A constant correction position (opposite reference pointers) is obtained by turning the photoelectric generator with the handwheel (*H*) so that zero phase relation is always indicated. It is said that only a few seconds are required for the operator to read the unbalance in either of the two selected correction planes. A selector switch determines which end is being read. The scale may be calibrated in practical units of correction such as inches of solder or depth of drilled hole. Operator is given immediate indication as to whether he has made too much or too little change in correcting the unbalanced part. "Dynograph" is quite flexible and may be readily adapted to various balancing jobs within its capacity. It operates on 110-volt 60-cycle lighting circuit and is designed for bench mounting. With a 40" bed length, maximum distance between bearings is 15" and maximum swing 14". "Dynograph" is furnished complete with motor drive, tubes, belts, instructions and technical data, etc., ready for operation. Vibration isolation spring suspension mount is available where considerable extraneous vibration may be encountered.—*R. B. Annis Co. 1101 N. Delaware St., Indianapolis, Ind.*

Four-inch Rheostats

New "Bulletin 69" Pressed Steel Rheostats are said to meet the need for a small, sturdy, power rheostat having a large number of steps and ample current carrying



capacity—a combination of features hitherto obtainable only in the more costly rheostats. These new rheostats are 4" in diameter with as many as 43 steps of control and are rated for 100 watts. Spacings through air and creepage distances between parts of opposite polarity and between current carrying and grounded parts meet the requirements of A.I.E.E., NEMA and Underwriters' Laboratories for 300-volt service. In addition to these characteristics, "Bulletin 69" Rheostats feature balanced contact arm, "dead" shaft construction and copper graphite contact shoes. They are available in front or back-of-board mounting, in single and multiple assemblies.—*Ward Leonard Electric Co., Mount Vernon, N. Y.*

Dust-tight Relay for Aircraft Applications

New dust-tight relay, especially designed for aircraft applications requiring high current-carrying capacity without sacrifice of compactness and light weight, is a solenoid-operated device with the normally-open contacts rated at 10 amperes d.c. These contacts will make or break 30 amperes at altitudes up to 40,000 feet. The coil contacts, and plunger are enclosed in a dust-tight housing, and the unit is corrosion-proof, meeting 200-hour salt-spray tests as stipulated by various government agencies. Relay can be furnished in a single-pole, single-circuit form with one normally-open and one normally-closed contact. Operating

THESE STEEL REEDS are the Heart of all "FRAHM" Instruments

In appearance, these reeds may resemble a paper of matches . . . but there the similarity ends. They are the heart of all Frahm Instruments for measuring speed, frequency and rate of vibration and are the *only* moving parts.

Each reed of the Frahm Instrument, like a pitch pipe, is accurately tuned to a definite period of vibration, and a number of reeds with an appropriate interval between each are grouped in a housing to form a matched set. When minute vibratory impulses enter the reeds through the frame on which they are mounted, individual reeds come into resonance and clearly indicate the frequency of the vibration. Being essentially simple and rugged in construction, and since there are no rotating parts to wear, instrument accuracy is indefinitely maintained.

This resonant-reed principle is incorporated in all Frahm Tachometers and Frequency Meters. Instruments are made in both hand and permanent mounting types for speeds or rates of vibration in various ranges between 900 and 30,000 per minute, or frequencies from 15 to 500 cycles per second.

We will gladly send you full details on any or all of these "Frahm" resonant-reed instruments and their applications. The following bulletins are available on request:

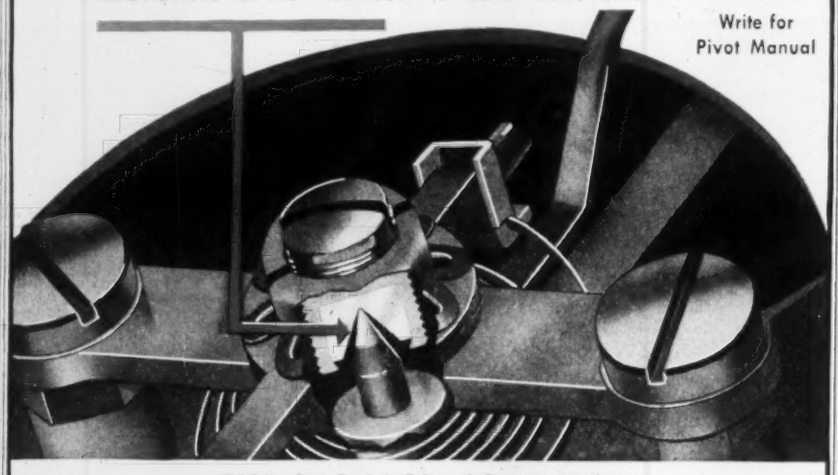
Frahm Tachometers, Bulletin 1590I
Frahm Frequency Meters, Bulletin 1695I

James G. Biddle Co.
1211-13 ARCH STREET *Electrical and Scientific Instruments* PHILADELPHIA, PA.

AEROPOINT TRADE MARK For Better Instrumentation

AEROPOINT PERMIUM PIVOTS for instruments are the most outstanding improvement in years. They assure dependable, precise, snap action electro-mechanical energy transformation. Alloy tips are lubricious, non-blunting, corrosion proof, smooth, dense, tough—with herculean resistance to wear and vibration abuse. No increase in friction with use. Reduces field service replacement and maintenance. Instruments will remain more accurate longer. *Insist on AEROPOINTS for the "heartbeat" of better instruments.*

Write for Pivot Manual



THE PARALOY COMPANY
600 S. MICHIGAN AVENUE • CHICAGO, ILLINOIS

"Only AEROPOINT pivots > > > > > > > > > > > are made with PERMIUM"

coil can be furnished for either 12- or 24-volt d-c. operation. Relay can be mounted in any position on a metal or non-metallic base. When relay is in energized or de-energized state, contacts will remain in open or closed position without chattering, even when subjected to mechanical frequencies of 5 to 55 cycles per second at 1/32" amplitude (1/16" total travel) applied in any direction. Relay is designed for use in an ambient temperature range from 95°C. to minus 40°C. and will withstand 95% humidity at 75°C. on 48-hour tests and operate immediately thereafter.—*General Electric Co., Schenectady, N. Y.*

Water Detector Lock

New "Type P15NH Electronic Water Detector Lock" (Fig. 1) indicates water seepage in gasoline storage tanks, commands pump and alarm; is supplied with "Type H31 Probe Fitting" (Fig. 2) which is mounted in a standard pipe fitting on top surface of the tank, probe rod projecting down through tank to the level at which water seepage is to be detected—usually three inches from bottom of tank.

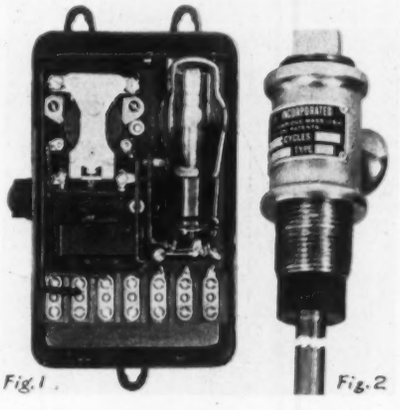
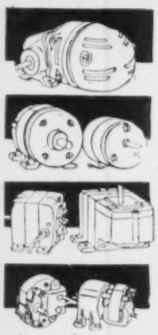


Fig. 1 Fig. 2

"Electronic Water Detector Lock" is located at any point remote from the tank and wired to the probe. While the probe rod is entirely immersed in gasoline and as long as water seepage has not reached the probe, no signal is given. When water seepage rises to contact the probe tip, an electrical circuit is completed through the water itself, and the water detector lock operates, turning off pumping equipment and actuating an alarm circuit. Standard "P15NH" operates on 115- or 230-volts a.c.; battery-operated "P15NB" is also available as standard. Water detector locks will handle output loads up to 10 amperes at 115 volts a.c. "Type P15NH" is supplied in a weather-proof pressed-steel housing. Explosion-proof housings are also available. Probe fitting "Type H31" is furnished in brass, stainless steel and other metals.—*Photoswitch Incorporated, 21 Chestnut St., Cambridge, Mass.*

Fractional H. P. Electrical Motors in War Quantities



Dependable motors for A.C., D.C., or Universal operation, from 1/3000 to ½ horsepower, with speeds of from 3000 RPM to 25,000 RPM, and with almost any geared speed desired with worm or spur gearing. Light in weight and compact. More than 26 standard and innumerable special types.

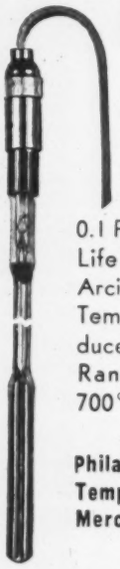
SpeedWay has capacity for any quantity, large or small, and can meet quick delivery dates even now.

SpeedWay will make motors *and units incorporating motors* to YOUR specifications and/or Army, Navy or Air Corps specifications.

Whether or not they can supply your needs, SpeedWay will give you prompt, courteous service. Send details and specifications for quotations or requirements for recommendations of the SpeedWay Technical Staff.

SpeedWay MANUFACTURING CO.
1839 S. 52nd AVE. CICERO, ILLINOIS

Philadelphia Merc-to-Merc Thermo-Regulators Feature



Mercury to Mercury Contacts : Increased Contact Capacity : Sensitivity within 0.1 F. Exceptionally Long Life and Stability : No Arcing : No Oxidation : Temperature Lag Reduced : Temperature Ranges adjustable to 700°F.

•

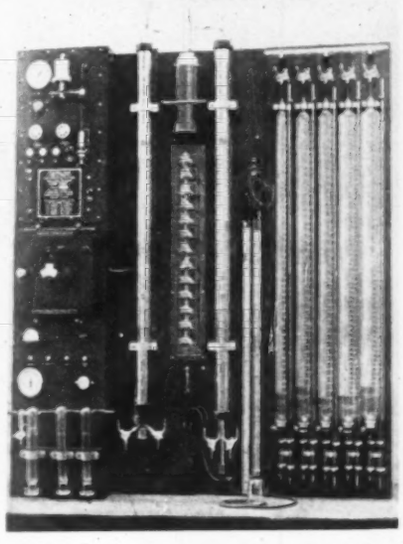
Philadelphia Merc-to-Merc Temperature Controls and Mercury Plunger Relays

•

The Philadelphia Thermometer Co.
915 Filbert Street -:- Philadelphia
WRITE FOR CATALOGUE No 104
Oldest Thermometer Manufacturer in Philadelphia

Low-temperature Fractionating Equipment

New "Semi-Robot" which has been added to Podbielniak's line of low-temperature fractionating equipment differs from the "Hyd-Robot" completely automatic recording low-temperature fractional analysis apparatus in that it is partly automatic. This new apparatus will have the same accuracy and efficiency as the "Hyd-Robot" equipment. Incorporated in the assembly are the high-efficiency "Super-Cool" columns, which are packed with 75 plus plate low hold-up "heli-grid" packings. Incorporated in the "Semi-Robot" panel is an arrangement for automatic control of reflux cooling and distillation pressure, plus manually set precise micro-distillate rate valve. The "Super-Cool" column used in this equipment is said to be based on entirely new principles. It makes possible the attainment of true adiabatic column temperature gradients despite



residual heat leakage through vacuum jacket and the tendency to thermal lag due to heat capacity of the column parts. This column assembly makes possible the close fractionation of even very close boiling gaseous mixtures, in reduced distillation time, with usually less than one liter and as low as ½ liter liquid air consumption per distillation. Applications in present wartime emergency: controlling alkylation, catalytic cracking, butadiene toluene extraction, and other War Effort processes, through continuous checking of percentages and ratios of the difficultly-separable isobutane, isobutene, butene-1, butene-2, butadiene and n-butane components.—*Podbielniak Centrifugal Super-Contactor Co., 8312 S. Chicago Ave., Chicago, Ill.*

Power Packages for Aircraft Subassemblies

A new driving mechanism—"power package"—has been announced for use in aircraft subassemblies. Designs depend upon applications, are available for bomb-door operation, landing-gear and wing-flap operation, operation of control and protective devices, etc. Power package combines in one compact unit a motor, brake, clutch, and limit switch as well as indicators, gears, and whatever else is required to do a specific job. Designed for 24-hour service, units can be obtained in ratings from about 1/100 hp. to 3 hp. Each element in the power package is reduced to its simplest terms to save weight and space. For instance, where either a brake or a clutch could be used, the brake is chosen because it has one moving part while the clutch has two. A new planetary gear system permits the use of a magnetic brake for some applications. Brake is of quick-acting friction type, stops

There's always the Sunshine
AFTER THE STORM!

As each ray of light breaks through the dark clouds, after the storm, to fill the earth with sunshine, so each PALMER Thermometer is bravely doing its bit to bring back the sunshine of Peace to the World.

Every PALMER Thermometer is finding its place in the network of equipment needed to back the boys at war because:

1—They are extremely accurate and correctly annealed;
2—Their sturdy construction means long life;
3—The easy-reading "Red-Reading-Mercury" column eliminates error.

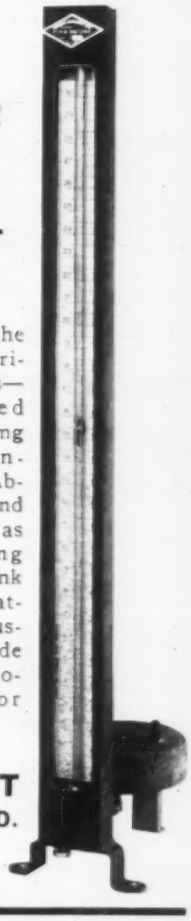
Just hesitate before you write that order for thermometers and you will be helping to win the war by careful selection of an instrument guaranteed to give satisfactory service.

(Catalog No. 300-D sent promptly)

THE PALMER COMPANY, Mfrs.
INDUSTRIAL, LABORATORY, DIAL & RECORDING THERMOMETERS
2511 Norwood Ave., Cincinnati, Norwood, O.—Canadian Plant: King & George Sts., Toronto

GET YOUR COPY OF THE NEW TRIMOUNT CATALOG!

● Describes fully the complete line of Trimount Instruments—Well Type, Fixed Scale U-Tube, Sliding Scale U-Tube, Inclined, Service, Absolute Pressure and other manometers as well as Indicating Flow Meters, Tank Liquid Level Indicators, etc. Fully illustrated—a real guide to the user of manometers. Write for your copy today.

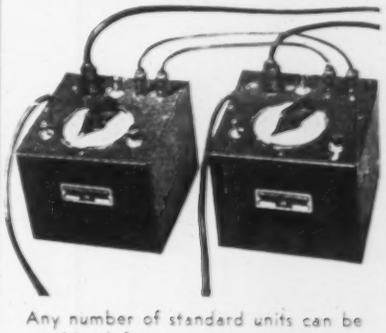


TRIMOUNT INSTRUMENT CO.
37 W. VAN BUREN ST.
CHICAGO, ILL.

PHOTOVOLT ELECTRONIC TIMER

An adjustable timing relay operating without clockwork or motor.

- High speed timing, from 1/20 sec. up.
- Immediate automatic resetting
- Push button and remote control



Any number of standard units can be combined for

Sequence Timing and Recycling in continuous operation.

For

Production and Process Control
Welding, Printing, Signaling
Labcratory Use and Life Tests

Write for literature

PHOTOVOLT CORP.
95 Madison Ave., New York City

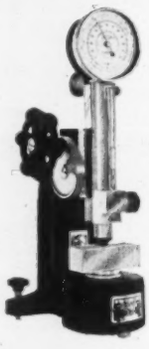
AMTHOR
TENSILE STRENGTH
TESTERS
for
PAPER
CORDAGE
RUBBER
LEATHER
WIRE
FLAT MATERIALS

PAPER FOLDING ENDURANCE TESTER
BURSTING TESTER
MICROMETERS (POCKET and DESK)
PAPER BASIS WEIGHT SCALES
CORDAGE SCALES
ALUMINUM FOIL SCALES
COMPUTING SCALES
RUBBER ABRASION TESTER
DEAD WEIGHT
PRESSURE GAUGE TESTER
TACHOMETERS
INDICATING and RECORDING
MERCURY COLUMN GAUGES

AMTHOR
TESTING INSTRUMENT CO. INC.
48 Van Sinderen Ave., Brooklyn, N. Y.

HARDNESS TESTING...

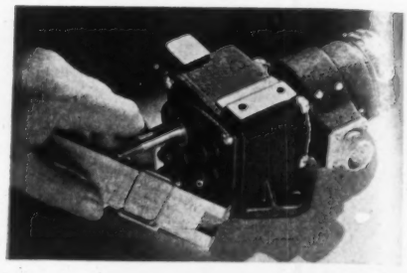
done WITH NO MENTAL HAZARDS. The SCLEROSCOPE has done it for the past 35 years.



In general use for specification purposes. Simple, sturdy. Comparatively inexpensive.

Illustrated bulletins free.

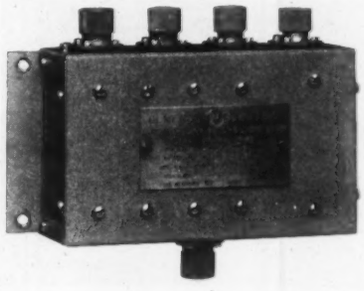
The Shore Instrument & Mfg. Co., Inc.
9025 Van Wyck Ave., Jamaica, N. Y.



motor quickly to prevent overtravel and consequent jamming of driven plane assembly. When power is off, driven equipment is locked in place by the brake, to eliminate creeping of such subassemblies as landing gear. — *General Electric Co., Schenectady, N. Y.*

Enclosed Ballast for Aircraft Panel Fluorescent Lighting

A new enclosed fluorescent-lamp ballast, especially designed for use in aircraft, is announced. This new ballast operates four 4-watt Mazda F lamps, designated as T-6 × 2½, FA-5 (pinless) blue F-6 lamp, for instrument-panel lighting. It operates from a 26-volt, 400-cycle power supply at all frequencies from 385 to 416 cycles. An input-voltage variation of 23.5 volts to 28.5 volts is permissible. The new ballast is light (2.10 lbs.) and small (approx. 3½" × 6½" × 2"). Operation is unaffected by a wide range of ambient temperatures up to 140°F.—*General Electric Co., Schenectady, N. Y.*



A NAME THAT SIGNIFIES STANDARD
LITTELFUSE

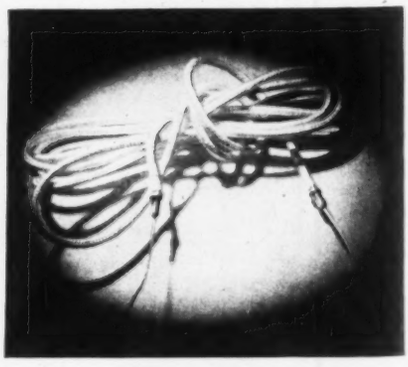
BETTER FUSE PROTECTION!

Consult us first on your fusing problems. We might be able to recommend a standard fuse that will improve your equipment. We are specialists in engineering panels and fuse protection to requirements.

LITTELFUSE INC. 4759 RAVENSWOOD AVE. CHICAGO, ILL.

Glass-insulated Flexible Heating Element

Available in any length, by the inch, foot or yard, a new low-power flexible heating element known as the "Glasohm" is for use particularly in limited space and also as a flexible power resistor. The resistance wire is wound on a fiber-glass core and is protected by a fiber-glass braided covering almost as flexible as silk. "Glasohm" heating elements can be provided with any type terminals. Ratings are from 1 to 4 watts per body inch depending on the application. Operating temperatures up



INSTRUMENT TRANSFORMERS

Split Core Current Transformers

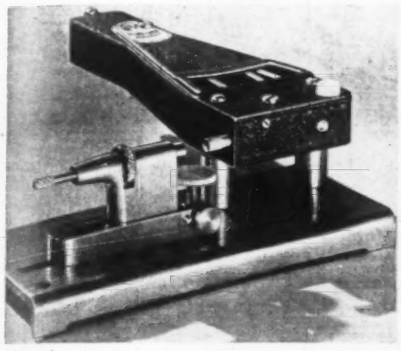
Special Instrument Applications

R. B. ANNIS COMPANY
1101 N. DELAWARE ST. INDIANAPOLIS, IND.

to ... F. Among applications: temperature-controlled ovens for oscillating radio crystals, heating aviation and marine instruments, localized heat for chemical apparatus and laboratory equipment, etc.—*Chemstat Mfg. Co., Inc., 285-7 N. 6th St., Brooklyn, N. Y.*

Visual Comparator for Rapid Production Inspection

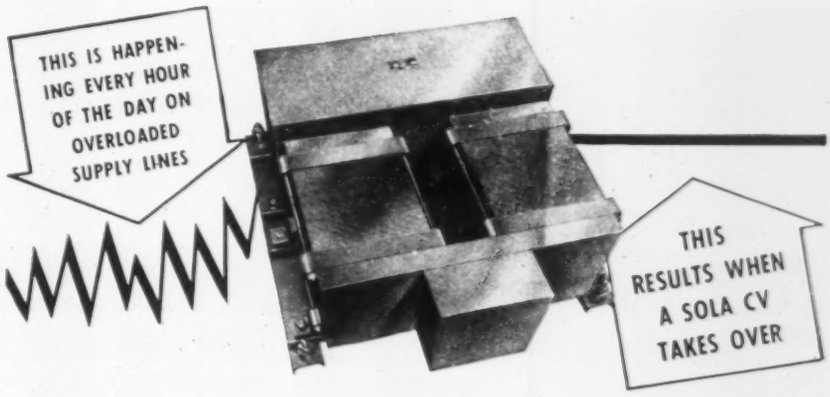
New "Micro-Chek" visual indicator comparator gage is an outgrowth of the effort of a Western New York manufacturer to convert its machinery and equipment to exclusive production of war material: it was originally designed to meet manufacturer's own large number of additional inspection requirements on precision parts. Instrument



has been developed to use a simple multiplying-lever mechanism and to put this multiplying device under the control of a push button. Used as a comparator type of gage, it is set by the use of two master parts, one having the limit of dimensional tolerance on the high side and the other having dimensional tolerance on the low side. Two limiting fingers on the instrument are set in this manner to arrive at the "go" and "not go" limits. Production parts thus may be compared to the master parts and then checked for "go" and "not go" limits simultaneously. Re-setting of tolerance indicators can be accomplished in a few seconds. Pointer stays in retracted position until button (white button in photo) is pressed. Gaging point pressure is adjustable from 2 oz. to 2 lbs. After putting this device into use in over 100 different inspection points, manufacturer decided to distribute it to others engaged in kindred work, believing that adoption would speed up the work of expert inspectors and also make it possible to train inspectors rapidly in industries where advancing war program requires enlarged personnel. It is said that "use has demonstrated that there is less fatigue among operators engaged in such delicate work." Two models are available: "Model A" multiplies movement 200 times; "B" 60 times. Prompt shipments to users who are able to furnish priority for their tool needs.—*Trico Products Corporation, Buffalo, N. Y.*

Tensile Testers

New table and floor model portable units of maker's tensile testing machines are announced. Expansion of scope and utility is exemplified by new table model illustrated. This is an "in-between-size" instrument—so that while small in size, it will physically check specimens up to a foot in length, also accommodating up to 9" width. It broadly covers tests of small objects and also goes up into the range of larger machines, for it handles up to 10,000 lbs. Versatility of instrument is said to be largely due to use of Dillon Dynamometer stress indicator, which permits wide limits of measurement with a uniformly small stress-reader. Height starts at 32" (table model) to 78" (floor type). Paper, plastics, metal, rubber, wood, etc., may be tested up



Stabilize your power supply at peak efficiency 24 hours per day

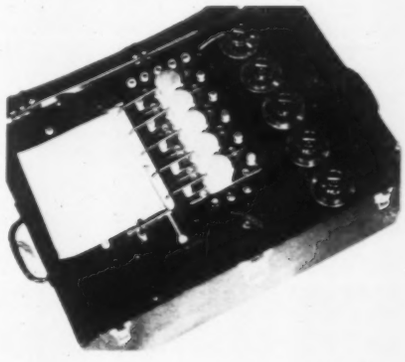
Your equipment, whether it is a vacuum tube, a laboratory instrument or a complex, electrically operated machine is designed for a rated line voltage. Any deviation from this value may mean damaged equipment, misleading results in laboratory research or a noticeable lack of uniformity in products and production schedules.

Sola Constant Voltage Transformers automatically provide perfectly regulated voltage that remains constant regardless of supply line fluctuations. They have no moving parts, are self-protected against short circuit, and require no supervision. They're on the job 24 hours per day.

Standard designs are available in capacities ranging from 15VA to 10 KVA or special units can be built to your specifications.

SOLA ELECTRIC CO.
2525 Clybourn Ave., Chicago, Ill.
Ask for Bulletin GCV-74

SOLA CONSTANT VOLTAGE TRANSFORMERS



GARCEAU VELOGRAPH
DIRECT WRITING OSCILLOGRAPH
Quintuplet Model
(Inkless writing on electrically sensitive paper)

Designed for study of vibration in aeroplanes, analysis of pressure in rotating and reciprocating machinery, seismography, oscillographic analysis of welding and other electrical equipment operating on commercial power line frequencies. This direct-writing oscillograph will operate in any position and in the presence of excessive vibration. Particularly adapted to automatic remote control operation. No fragile crystals, permanent magnets nor moving coils.

ELECTRO-MEDICAL LABORATORY, INC.
HOLLISTON, MASSACHUSETTS, U.S.A.
Makers of the Garceau Junior Electroencephalograph

Jones Tachometers
Continuous Indicating
Centrifugal Type

Portable and Stationary
Indicating Speed and Total Run.
Flexible Shaft, Belt, or Electric Drives for Remote Indicating.

•

Types Available for Every Industry

Locomotives, Steam, Gas, and Electric. Baking Time for Ovens, Dryers, Etc.
Centrifuges, Textile Machinery
Marine, Fire Apparatus
Automotive, General Machinery

Submit Your Problems to Us

JONES MOTROLA SALES CO.
438 Fairfield Ave., Stamford, Conn.

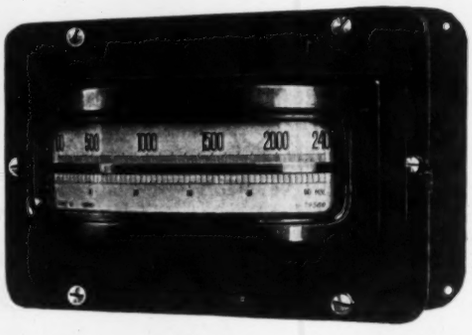
WHAT do you need in a PYROMETER ?

SENSITIVITY **RESISTANCE**
DURABILITY **SIMPLICITY**

Engelhard Direct Deflection Indicators have all these features . . . Accurate sensitivity to the most minute voltage variations due to suspension type construction . . . High resistance per millivolt and no appreciable error when used with thermocouples of different resistances and on connecting leads of considerable length . . . Sturdy construction, adapted to use under severe conditions without danger . . . So simple that instant readings may be made directly in either millivolts or temperatures by someone unfamiliar with the principles of pyrometry . . . On kilns or furnace installations, where "spot readings" are desirable—the Engelhard Rotary Switch permits separate readings from many points.

Write for Catalog

PORTABLE MODEL P-1



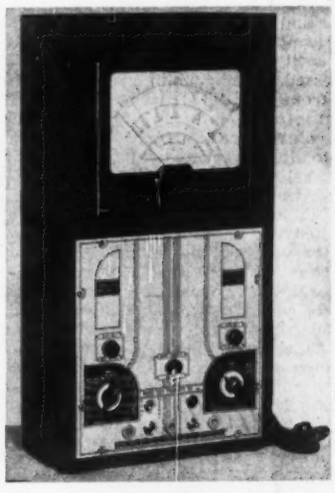
WALL TYPE W-1

CHARLES ENGELHARD, INCORPORATED
90 CHESTNUT ST. **NEWARK, NEW JERSEY**

to 15,000 lbs., a number of capacities being now available in this range. Construction features include free floating bearing-supported dynamometer pins; 100% overload protection; universal loading; adjustment for temperature variation.—*W. C. Dillon & Co., 5410 W. Harrison St., Chicago, Ill.*

Multi-tester

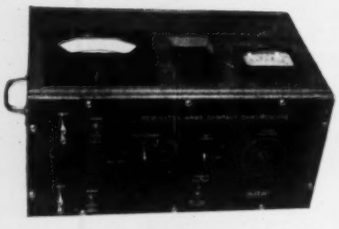
Maximum sensitivity, flexibility and utility are said to be combined in new "No. 662" vacuum-tube multitester; actually an electronic voltmeter, ohmmeter and capacitymeter in one, with "an extremely wide and useful range of applications in laboratory and production-line tests, service work, etc." It is a vacuum-tube voltmeter on a.c., not a rectifier type. It furnishes capacity readings directly in microfarads, with a measurement ratio of 40,000,000 to 1. Designers forestalled all danger of shock on low-capacity measurements. There are no



test deals to short and no resetting is necessary when changing ranges. Indicating instrument cannot be damaged by checking a live resistor or by using a low range on high readings. Error due to line voltage fluctuation is eliminated by a VR105-30 regulator tube and associated circuits. Two models: one with a sloping panel and 4½" indicator, also an upright-style companion model (No. 622-V-7) with an 8½" rectangular indicator affording long scales for easy reading. Both testers have similar performance characteristics. Both are complete with leads and readily-accessible batteries, tubes and pilot light.—*Radio City Products Co., Inc., 127 West 62th St., New York City.*

REMINGTON ARMS CO.

CHRONOSCOPE



Accurate Within 1% Between 1 & 200 Milliseconds

Inquiries Invited

Dynamometers, wattmeters, milliammeters and voltmeters. Also ultrasensitive meters both for A.C. & D.C., fluxmeters, electrostatic voltmeters from full scale 120 volts to over 20,000 volts, thermocouples, earth current meters, cable testers, etc.

Special Apparatus Built to Order

RAWSON ELECTRICAL INSTRUMENT COMPANY

110 Potter St. Cambridge, Mass.

Branch: 15 East 26th St., New York City

Representative: E. N. Webber
4358 W. Roosevelt Rd., Chicago, Ill.

PORTABLE

WHEATSTONE BRIDGE

A high grade instrument for measuring resistances from a fraction of an ohm to 10 megohms. Contains a 4-dial rheostat, ratio dial, galvanometer and battery, all enclosed in a substantial walnut case. Nine coils per dial. Accuracy .1%. Built to endure.

Cat. No. 1050—Portable Wheatstone Bridge with Murray and Varley Loops. . .$110.00

Cat. No. 1052—Portable Wheatstone Bridge without Murray and Varley Loops.$90.00

Send for Bulletin No. 105

RUBICON COMPANY

Electrical Instrument Makers

Ridge Ave. at 35th St. Philadelphia, Pa.

BEFORE YOU BUY ANY COMBUSTION TEST SET

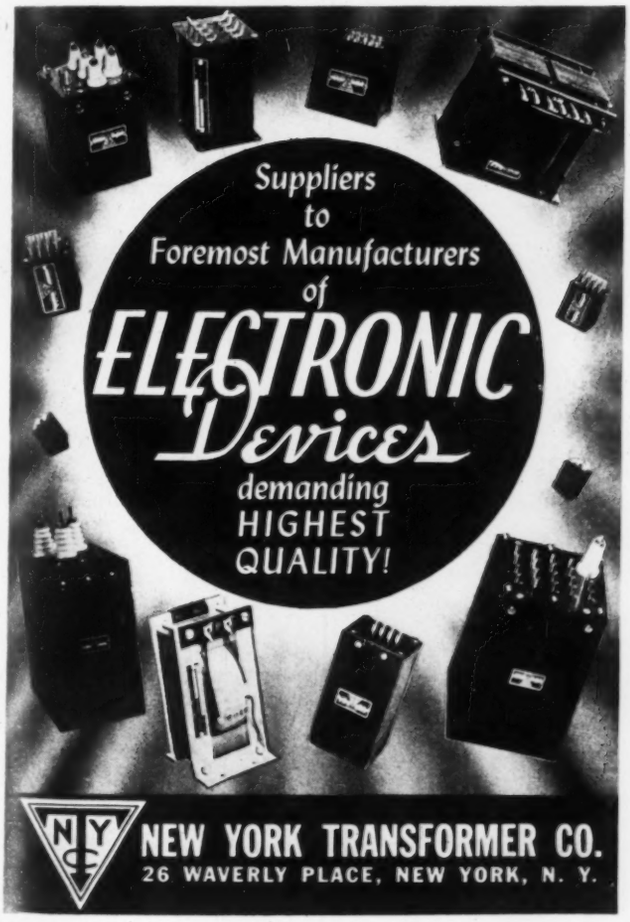
Read This FREE BOOK!

Learn what is meant by combustion testing—the importance of CO_2, draft and flue gas temperature. Learn how to run an orsat, how to cure chimney troubles—how to check an installation. This book tells all and is sent without cost or obligation. Send name and address—

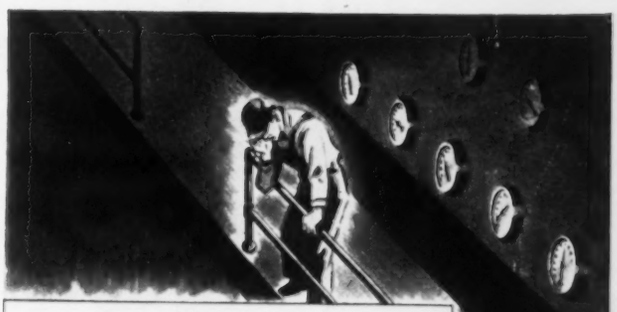
925 Eighth Avenue

CLIP AD and MAIL to

THE HAYS CORPORATION
SINCE 1901
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.



NEW YORK TRANSFORMER CO.
26 WAVERLY PLACE, NEW YORK, N. Y.



HOW OPTICS SERVED A CHEMICAL PLANT

A troublesome operation in a well known chemical plant was the reading of inaccessible gauges. Every twenty minutes an employee would climb a fifty-foot ladder and call successive readings down to the control board below. Today all these measurements are taken instantly by the engineer on duty, without leaving his chair and with far greater accuracy. Control has been greatly improved; unnecessary time and labor eliminated.

This improvement was an accomplishment of *optical design and manufacturing*, a typical example of how Perkin-Elmer engineers can improve industrial efficiency. Frequently the amazing science of optics can "team up" with chemical, mechanical or electronic methods to provide the answer to otherwise insoluble problems.

Despite the fact that The Perkin-Elmer Corporation facilities are and will be devoted entirely to the war effort for the duration, we shall welcome your letter describing present problems or future plans. If we can be of service now or in the future, we shall be glad of the opportunity.

THE PERKIN-ELMER CORPORATION
GLENBROOK, CONNECTICUT

MANUFACTURERS OF PRECISION LENSES • PRISMS and MIRRORS
OPTICAL DESIGN AND CONSULTATION

Timers

Designed and made for those who appreciate and demand dependability and accuracy in such instruments.

Among our extensive line are the following two popular models.

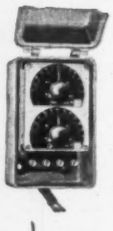
MULTI-CONTACT TIMER

Automatically controls a sequence of "on" and "off" operations of a single or a multiple number of electrical circuits in accordance with a predetermined operating program.

Used to control a series of machine operations in definite order — to automatically reverse or alternate in operation a group of motors, machines, or devices, etc.

DUAL CYCLE TIMER

with both "on" and "off" operation individually adjustable Repeat Timer especially adapted to industrial applications which require maximum flexibility. Has two reset timer mechanism mounted on a common base plate each with its individual micrometer setting knob and dial.



Just what are Your Needs?

by

Cramer

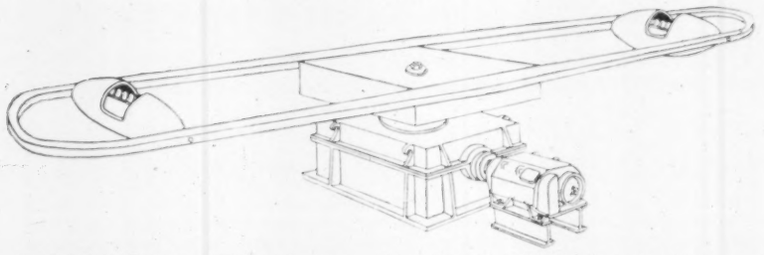
The R.W. CRAMER COMPANY Inc.
CENTERBROOK CONNECTICUT

Instruments in the War Effort

Centrifuge to Test Pilots' Reactions to Acceleration

NOT ONLY are new planes subjected to exhaustive tests in U. S. Army Air Force laboratories, but pilots are given various tests to make certain that the speed and maneuverability of a new plane will not exceed a pilot's physical limitations.

It is recognized that the limitations of a pilot are affected by rate of acceleration. This factor will soon be investigated by flight surgeons in an eastern laboratory with the help of a "human centrifuge" which will reproduce acceleration conditions corresponding to all known or desired air manoeuvres.



The centrifuge, for which the General Electric Company is now building an electric drive, consists of a horizontal boom with a driving shaft at its center. Cockpits are mounted near each end of the boom, 20 feet from the center shaft. [Quite a difference from the dimensions of the familiar centrifuge for test-tubes!]

The boom will turn as rapidly as 54 revolutions a minute, at which speed the radial acceleration at the cockpit radius is 20*G*. The centrifuge will be able to reach this speed in only five seconds from a standstill. It will decelerate in the same length of time thus simulating far more than the severest operating conditions now encountered in a plane.

However, normal tests will average from 15 to 20 seconds running time, with lower values of acceleration, since a pilot would black out before reaching 54 r.p.m. in such a short time as five seconds. The shortest test run is expected to be approximately five seconds and the longest to be three minutes.

To simulate the effects of any desired air manoeuvres, a flight surgeon will mark a pattern of speed changes on a chart in a heavy line. This line is scanned by a G-E control device which then commands the driving motor to follow the prescribed speed-change schedule. Flight surgeons will observe the tests from a glassed-in control room, where master switches, speed selecting and recording devices, and testing instruments will be located. A separate room will house the control panel and an adjustable-voltage motor-generator set.

100,000,000-volt X-rays and Electrons

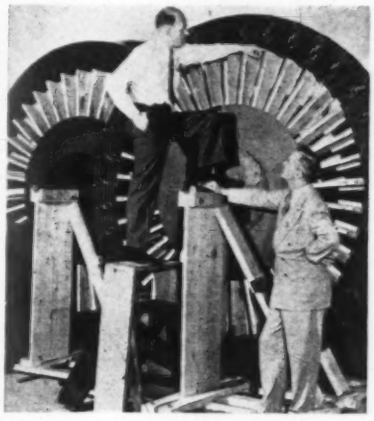
HOUSED in a special building with three-foot concrete walls, an induction electron accelerator which will speed electrons to energies of 100,000,000 volts, and which will produce x-rays of the same power, is being constructed as an addition to the General Electric Research Laboratory. It was inspected in August by the National Inventors' Council, of which Dr. William D. Coolidge, G-E Vice President and Director of Research, is a member. This giant instrument will give electrons energies far higher than have ever been given by a human agency before. One of the investigations with the equipment will be a determination of the maximum thicknesses to which x-rays can usefully be applied for examination of armor plate and other very thick cross sections. Eight inches of steel represents the practical limit for convenient use of the present million-volt industrial x-ray unit.

Dr. Ernest E. Charlton, head of the x-ray section of the G-E Laboratory, and W. F. Westendorp, have been responsible for the design and construction of the new accelerator. Its main part will be an electromagnet weighing 125 tons. Between the 78" diameter pole faces where the magnetic field will be most intense, will be a six-foot hollow glass "doughnut," inside which the electrons will be speeded in vacuo. The cross section of the doughnut will be elliptical. 5" high and 8" across, with ¼" wall thickness. It will be assembled

of molded sectors, which are being made by the Corning Glass Works.

The doughnut is a merry-go-round for electrons. Starting from the filament of an electron gun (like that of a cathode-ray tube) they will be whirled around a quarter of a million times in 1/60th of a second, on each trip receiving a 400-volt push. Their total travel will be about 800 miles, which means that their path has to be guided with extreme accuracy. As Dr. Charlton stated, it is "like shooting on a curve for a distance as great as from Schenectady to Chicago and hitting a three-inch target."

The operation of the electron accelerator is similar to that of a transformer: the "primary" consists of two 98" coils of insulated copper conductor 0.88" in diameter. Each coil has forty turns and contains a ton of metal. The



Dr. E. E. Charlton, right, and W. F. Westendorp, with the large coils to be used in the induction electron accelerator

"secondary" consists of the flow of electrons in the evacuated space of the accelerator doughnut.

The electrons are speeded up during the first quarter of each cycle of the 60-cycle a.c. At the end of this quarter-cycle the high-energy electrons will strike a target and generate a beam of highly penetrating x-rays, which will emerge from the machine, together with scattered high-speed electrons. Even *these* electrons will be able to penetrate two inches of steel. The control room is outside the thick wall, and a periscope using four mirrors will permit the operator to watch with safety. Above the control room is the largest single bank of capacitors in the country, with a capacity of 24,000 kva.

The induction electron accelerator bears a superficial resemblance to the cyclotron, but it is quite different. The cyclotron speeds positive particles by whirling them around in the field of a powerful d-c. magnet. The particles are accelerated only when they cross the gap between the D-shaped semicircular boxes, inside which they coast in a curved path on the rest of their journey. In the accelerator the electrons are speeded continually, and reach almost the speed of light.

PERMANENT MAGNETS

The Arnold Engineering Company produces all **ALNICO** types including **ALNICO V.**

All Magnets are completely manufactured in our own plant under close metallurgical, mechanical and magnetic control.

The Arnold Engineering Company freely offers engineering assistance in the solution of your magnetic design problems.

All inquiries will receive prompt attention.

THE ARNOLD ENGINEERING COMPANY

147 EAST ONTARIO STREET
CHICAGO, ILLINOIS

INVEST 10% IN WAR BONDS AND STAMPS

R. S. PORTABLE GAUGE TESTER

A dead weight gauge tester compactly designed for portable use. The tester and weights are carried in a hardwood carrying case suitable for operation in shop, plant and field.

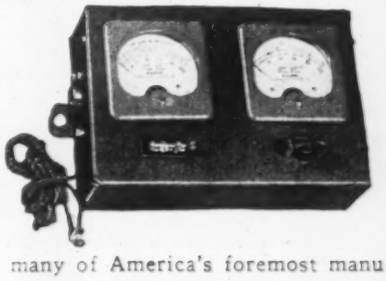
Catalog 26A for Scientific Instruments.

THE REFINERY SUPPLY COMPANY

Manufacturers, Jobbers, and Importers
SCIENTIFIC LABORATORY AND POWER PLANT EQUIPMENT

—Main Office and Plant—
621 E. 4th Street, Tulsa, Oklahoma

—Branch Office—
1309 Capital Avenue, Houston, Texas



TRU-VAC VACUUM GAUGES

(PIRANI TYPE)

Shown at left is meter box of our model No. 6 gauge.

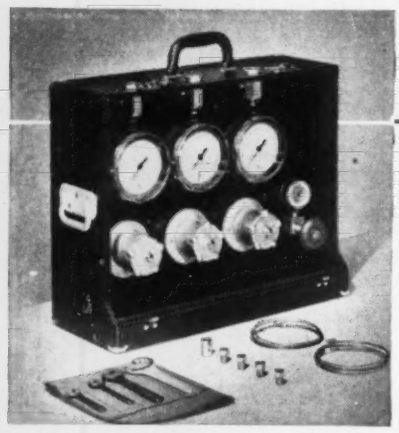
This gauge successfully used by many of America's foremost manufacturers.

Send for circular on our new low priced D.C. operated gauge.

CONTINENTAL ELECTRIC CO.

GENEVA, ILLINOIS

The GROVE Pneumatic Gauge COMPARATOR



GROVE SIMPLICITY ACCURACY SAFETY

The Portable Method of Checking All Types Of Pressure Gauges

- Compact, portable and fully self-contained.
- Built-in high capacity rechargeable air cylinders.
- Precision laboratory test gauges accurate to within ¼ of 1% full scale.
- Completely equipped with tubing, connections and accessories.

Figure the amount of time, trouble and money you save when you check your pressure gauges "in-place" without removing them from their panels or mountings; without disturbing existing line connections. The portable Grove Pneumatic Gauge Comparator gives you this fast accurate means of accurately checking any service gauge in service. Write today for Bulletin 300.

GROVE REGULATOR COMPANY
1194 67th Street, Oakland, California
Branch Offices:
5644 Navigation Blvd., Houston, Texas—30 Rockefeller Plaza, New York City

GROVE GROVE SIMPLICITY ACCURACY SAFETY *Pneumatic Gauge* COMPARATOR

THE KING PIN!
The Proven, basic, precision Cartridge, from which all other Fenwal Thermoswitches are derived.
Let us quote you on a standard Thermoswitch design that fits the needs of your defense contract. (If your job is an unusual one we will design a "special" for you!)
Ratings: —100 to 600°F., 10 amperes or 25 amperes, 115 Volts A. C., sensitivity ±.1°F.

6 MAIN STREET
ASHLAND, MASSACHUSETTS
Fenwal
INCORPORATED

Training Military and Civilian Personnel

(Concluded from Page 522)

text material and the division into three specialists' courses was a simple matter. It did take some work to arrange the courses of study, but that also was accomplished and at present the school is functioning smoothly with both programs in operation.

In the military courses, the student is trained as a specialist in only one phase of aircraft instrument work. His training may be on (1) pressure instruments, (2) electrical instruments or (3) gyroscopic instruments. He is trained to do complete overhaul on all types of instruments that fall within the classification, so that he will be able to "Keep 'Em Flying" even if there are no replacements available.

In this way, American School of Aircraft Instruments is doing its part in the War Effort and is looking forward to the time when peace will come and we will be able to again turn our efforts to the training of aircraft instrument mechanics for development of commercial aviation which is sure to follow.

Shop Kinks

(Concluded from Page 528)

face plate and then placing the drill in a chuck in the tail stock. The secret of good holes lies in the drill, however.

If a hole slightly smaller than the diameter desired is drilled first, and then a drill of the correct diameter is

ground especially, an accurate, smooth-walled hole will result.

To prepare the correct diameter drill, merely chamfer both corners of the cutting edges where they join the sides of the drill. This radius prevents grooves being gouged by the sharp corners of the drill.

Overhaul Procedure—Pendulum Assembly

(Concluded from Page 523)

5. If the vane settings are incorrect, bend the vanes to make the correct setting. Extreme care must be used so as not to break the solder joint between the vane and shaft.

6. If the end play is too great, rest the pendulum assembly on one end of the shaft, place a hollow punch over the other end of the shaft and tap lightly with a hammer until the end play has been reduced to the desired amount. After doing this, check carefully for broken solder joints. If the end clearance is excessively large, it will be necessary to melt the solder by use of a soldering iron and move the vane down on the shaft.

7. Hold the pendulum assembly up, so that one of the four flat sides is horizontal; and check the clearance between the vane and body against a light. The clearance should not be greater than the thickness of the spacer washer between the vane and the body. The vanes must swing perfectly free and must not clear the pendulum body at the holes more than is necessary to give perfect freedom. Bend the vane as much as necessary to line it up with the body and have perfect freedom. Repeat this operation with the other three vanes. Extreme care must always be used in bending.

8. Check each pair of vanes for freedom by holding the pendulum assembly in its normal position with the bottom resting on the bench. Swing the vanes back and forth several times and allow them to come to rest. Repeat this several times. They should stop in the same position each time. Finally, move each pendulum vane off to first one side and

the the other and allow it to return to its normal position. It should return to the same position each time; and it should make at least four half-swings before coming to rest.

9. If the shaft holes in the pendulum body are so elongated that the vanes rub on the body, it will be necessary to overhaul the pendulum assembly.

10. To disassemble the pendulum assembly, first cut the shafts on the inside of the pendulum assembly with a pair of diagonals. Be careful to remove all burrs with a file before removing the shafts, so that no damage will be done to the holes when the pieces are removed.

11. Lap the four sides of the pendulum body until smooth and clean. Polish each flat side with a fine Arkansas stone until a mirror finish has been obtained.

12. In the overhaul of the pendulum assembly, three sizes of shafts are used: 0.063", 0.065", and 0.068". The material is stainless steel, centerless ground round shaft. The length of the shaft used in the pendulum assembly is $1\frac{7}{16}$". Choose the diameter shafting that just fits the holes in the body. Polish the shaft to a mirror finish and burnish the body holes with the polished shaft. Square off the ends of the shaft for approximately $\frac{1}{16}$" from each end.

13. Remove the old pieces of shafting from the pendulum vanes. Lap the back and face of the vanes until smooth and clean. Polish until a mirror finish is obtained. Remove all solder from the countersunk holes in the front side of the vanes with a No. 27 drill. Using the same drill, countersink the back of the vanes approximately 0.005" (five thousandths). This is to remove any burrs that might cause trouble.

14. Broach out the vanes from the front side with a broach so that the final diameter is approximately 0.0002" to 0.0003" (two to three "tenths") less than the size of the shafting to be used. These holes should be small enough so that the shafting will have to be tapped into the hole from the back side of the vane. This prevents the solder from running down the shaft and sealing the spacer washer to the vanes; and also keeps the vane securely in place prior to soldering.

15. Polish four spacer washers on a fine Arkansas stone.

16. Place one of the upper shaft vanes face down on a bench block and place a shaft in the vane hole and tap it until the shaft extends about $\frac{1}{16}$" through the vane. Be certain that the shaft is perpendicular to the vane. Place this shaft into the high shaft hole on the pendulum body, holding the shaft on the inside of the pendulum body. Adjust the vane on the shaft so that it is parallel to the pendulum body. Remove the vane and shaft and place a spacer washer on the shaft. Again place the shaft into the body hole, holding the vane in position; check the clearance between the body and the vane at the free end of the vane. This clearance must not be greater than the thickness of the spacer washer. Solder this vane on the shaft. Then place a spacer washer over the other end of the shaft and with hollow brass punch, tap second vane on shaft and solder. Adjust vanes for end play. (This end play should be barely perceptible.)

17. Repeat above operation in other set of vanes. Clean thoroughly, being sure to remove all soldering flux. Wash thoroughly and clean in jeweler's rejuvenator. Wash assembly in clear warm water until all traces of rejuvenator have been removed and dry under clean low-pressure air.

18. Check all clearances, adjustments and freeness of assembly.

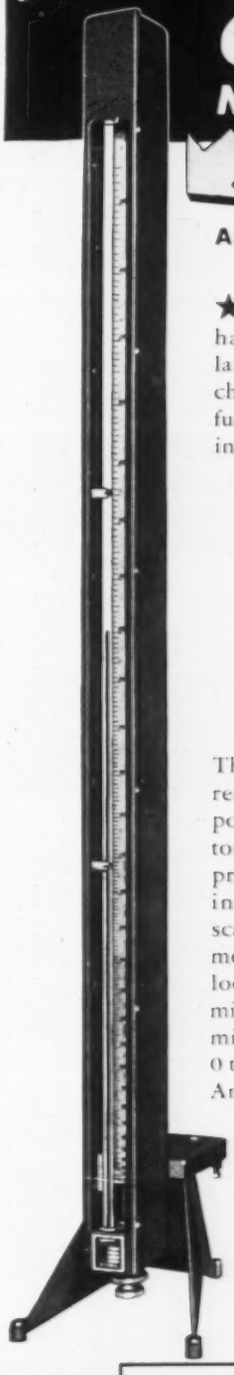
19. Check rubber pendulum buffer on the pendulum assembly used in the Gyro-Horizon. If the buffer is worn, loose, cracked, sticky or hard, replace with new buffer.

20. Check body roller and stud assembly on pendulum assemblies used in Bank and Climb units. This roller must be perfectly free without appreciable side play, and absolutely free from rust, flat spots or grooves. If any of these

MERIAM

Announces

THE "8 in 1" MANOMETER



AN AIRCRAFT INSTRUMENT TEST MANOMETER

★ This manometer, Model A-538, has an extensive application in laboratory and field servicing for checking calibration to determine functioning of aircraft instruments, in particular:

- Altimeters
- Air Speed Indicators
- Rate-of-Climb Indicators
- Fuel Pressure Gauges
- Manifold Pressure Gauges
- Suction Gauges
- Automatic Pilot sylphons and actuating diaphragms; etc.

The instrument is of the direct reading well type design incorporating an eight sided scale selector, permitting the selection of proper scale for particular aircraft instrument being checked. All scales are adjustable to suit barometric conditions in any specific locality and are direct reading in miles per hour-knots-pounds-inches-millimeters, etc. The range is from 0 to 61 inches of mercury or water. An integral return well prevents loss of indicating fluid.

The manometer is fully described in Bulletin 22. Copy will be mailed on request.

THE MERIAM COMPANY
1971 West 112th Street
Cleveland, Ohio

MERIAM
SINCE 1911
★

MANOMETERS, METERS AND GAUGES FOR THE ACCURATE MEASUREMENT OF PRESSURES, VACUUMS AND FLOWS OF LIQUIDS AND GASES

The Improved "ALNOR" PYROCON
for surface temperatures

features

Figure 1

1. ENLARGED ASSORTMENT of thermocouples all instantly interchangeable *without change in instrument calibration.*
2. Choice of rigid or flexible arms INSTANTLY INTERCHANGEABLE.
3. Choice of seven standard temperature ranges.
4. Unusually heavy and rugged movement essential in a portable pyrometer.
5. Greater accuracy. Construction of thermocouple assembly eliminates junction errors.

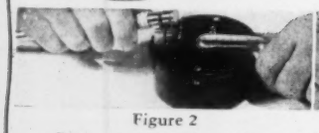


Figure 2

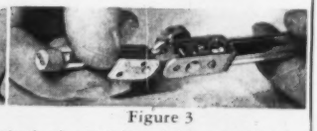


Figure 3

Figure 2 shows the unique method of attaching rigid or flexible connecting arm. Figure 3 illustrates easy attaching of thermocouples to arm yoke.

For full details write for Folder 3511

Illinois Testing Laboratories Inc.
142 West Hubbard Street Chicago, Illinois

HYDROMETERS

H-B hydrometer scales are individually and securely fastened with heat resisting cement. Breakage is minimized by the design and unit is easily cleaned. Simplicity of construction permits prices within reason for industrial use. Write for illustrated catalog.

H-B INSTRUMENT COMPANY
INCORPORATED
2525 N. Broad St., Philadelphia, Pa.
PRECISION SCIENTIFIC INDUSTRIAL INSTRUMENTS
H-B THERMOMETERS

conditions exist and cannot be removed by ordinary means of polishing, replace the body roller stud assembly. Lubricate the roller with one very small drop of Sperry Instrument Oil. Check the roller in the bail ring groove. Roller should have approximately 0.001" play.

21. In the event the shaft holes in the pendulum body are worn so badly that shafting larger than 0.068" would be needed to overcome side play, it will be necessary to rebush the body holes as follows:

(a) Run a $\frac{3}{32}$" drill through the body holes.

(b) Make four bushings of bronze or brass $\frac{5}{64}$ long by 0.096" outside diameter.

(c) Drill a 0.0625" hole through the center of the bushing.

(d) Tap these bushings into the body holes. They should be a press fit.

(e) Broach out holes to equal the size of a 0.063 shaft.

(f) Proceed on the overhaul of the pendulum body as previously mentioned.

22. The bushings for the pendulum vanes are the same but for length, which is $\frac{1}{8}$" long. The procedure for installation is the same as for body bushings.

(The Economy Rejuvenator used for this overhaul may be obtained from C. & E. Marshall Co., Jewelers' Suppliers, Chicago, Illinois.)

This Relative Thing Called "Precision"

(Concluded from Page 509)

for size and concentricity with the inside of the bushing; and also at the same time inspecting the squareness of the end of the bushing with its axis. All the above data can be quickly determined on the one gage.

In conclusion I would like to summarize the reasons why visual gages are supplanting old style conventional gages so rapidly. First—the elimination of the human element. Varying degrees of sensitivity on the part of the inspector are eliminated because errors are magnified so that they are visible to the inspector. No one as yet has found a way to magnify the sense of touch. Second—the speed of dial indicators. You instantly see the amount of error in the indicator. Moreover, you can not only see the condition of one dimension; but, due to the adaptability of dial indicators, these can be arranged so that several dimensions can be inspected simultaneously. Third—dimensions can be inspected with relation to one another, an operation which is practically impossible with solid or conventional type gages. Fourth—dial indicators though they may wear can be reset whereas conventional gages which wear become useless. Fifth—adaptability of dial indicators is one of the strongest assets. They can be applied in so many ways, in so many positions. They lend themselves readily to most gage problems.

The Pitfalls of Temperature Measurement

(Concluded from Page 499)

ployed, large errors may result from variations in the temperatures of the capillary and spring. The compensating means is never perfect, so errors creep in as these temperatures approach extremes. Thus we find it advisable to avoid placing the capillary or instrument where wide variations in temperature can be expected. The spring of this instrument is usually subject to large stresses, so we must be careful not to overheat the bulb. However, a small permanent strain of the spring can be readily corrected for because the scale in this case is nearly uniform. There is a more or less general impression that this mercury thermometer is subject to large errors accompanying changes in the height of the bulb relative to that of the rest of the system. There will be no appreciable error provided that the pressure in a stiff-walled bulb is kept well above the vapor pressure of the mercury. Since both the internal pressure and the vapor-pressure vary with temperature, a safe height a

one temperature of the bulb may not be safe at another temperature. If heights approaching 100 feet from bulb down to spring are contemplated, the maker of the instrument should be consulted.

Thermoelectric Thermometers

The pitfalls which we have not mentioned in the general discussion are found principally in loose electrical connections and dirty switches and slidewires, also in exposure of connections between wires of different thermoelectric properties to varying temperatures. To a lesser extent we are troubled occasionally by grounds and by leaks from power circuits to thermoelectric circuits. It is well known that the connections from a thermocouple to a millivoltmeter must be tight or else the instrument will read low. To be sure, a loose connection to a potentiometer is less serious, but errors nevertheless creep in. The sensitivity required for balancing is lowered. The errors caused by leaks and grounds are increased. The thermoelectric effects of decreased thermal conduction across connections are increased. An open circuit may make a potentiometer appear to be balanced.

A properly designed housing for the head of a thermocouple—where it is connected to extension leads—serves to keep both of these connections at the same temperature. This is not important where iron-constantan couples are connected to iron-constantan leads, but it is very important where chromel-alumel couples are connected to copper-constantan leads, and in some other cases. The head of a thermocouple may get rather hot, when a large e.m.f. will develop at the copper-chromel connection and another one at the constantan-alumel connection. These e.m.f.s will be of opposite sign, and will be nearly equal if the temperatures of the connections are nearly the same and not above 150° F. Above this temperature the two couples do not agree.

Let us look at the other end of the extension leads. These connections must also be enclosed. A little farther in the circuit and we come to a reference junction compensating resistor, perhaps. This will be found to be made of nickel wire. The change in the *IR* drop across this resistor is supposed to equal the change in the net e.m.f. of the reference junctions for any change of temperature. Of course we shall find these connections near the resistor, possibly in a well. But we cannot expect to be able to exactly match the change in *IR* drop in the resistor with the change in e.m.f. of the junctions for wide limits of temperature and for all kinds of couples. The agreements are pretty fair, however, and only small errors result at reasonable limits of temperature.

It is apparent then that the best results are obtained from keeping the instrument at a uniform temperature, at least not permitting rapid changes. Temperature gradients within the instrument may result not only in a difference in temperature between the nickel compensator and the reference junctions but may set up—in recorders, for example—undesirable stray e.m.f.s at slidewire contacts and moving switches.

Inhomogenous thermocouples can be the source of serious errors. For example it is next to impossible to determine whether or not there is sufficient immersion if the couple is inhomogeneous. The inhomogeneity may include a limited part of the couple. This is likely to happen when it has been installed in a muffle furnace with its hot end in the muffle and its middle part in the combustion space. Occasional inspections of installed thermocouples and protection tubes are always advisable. The replacement of a worn-out couple with a new one may result in peculiar situations. The user may have thought for years that the worn-out couple had been bought from a certain maker. Perhaps he thought it was a 13% rhodium alloy with platinum. So when he put a new couple of this type in its place the results were disastrous and possibly every other source of trouble imaginable was examined before it was learned that the old couple was a 10% alloy. The moral of this is—thermocouples are not easy to identify if they are not marked.

In the use of a potentiometer there are some very simple operations which are sometimes carelessly spoiled. For example, the galvanometer *should* be kept on its open circuit

In Hundreds of VITAL NERVE CENTERS

Photo Courtesy Lockheed Aircraft Corporation

KESTER CORED SOLDERS won't let go!

• In the instruments of measurement and control in a fighting machine—built to "take it and dish it out"—Kester Cored Solder is worth its weight in gold! Circuits sealed with Kester are permanently trouble-free—as dependable as the tank, plane or ship itself.

• Kester Rosin-Core Solder, especially designed for electrical use, contains a patented, plastic rosin flux that does not cause corrosion or injure insulating material. Kester Acid-Core Solder, for general applications, makes a tight, clean, permanent union.

• Kester Cored Solders are available in a wide range of core and strand sizes, one of which is exactly suited to any production requirement. All are superior in quality—they resist bending, vibration, shock, contraction and expansion.

• Let Kester engineers assist you with any production problem solder may help to solve. Write fully—there's no obligation.

KESTER SOLDER COMPANY
4216 Wrightwood Ave., Chicago, Illinois
Eastern Plant: Newark, N. J.
Canadian Plant: Brantford, Ont.

KESTER
Cored Solders
STANDARD FOR INDUSTRY

Automatic
Temperature Control
IT HAS MADE QUANTITY COMPATIBLE WITH UNIFORMITY
TODAY many heat treated products can be exactly duplicated in limitless quantities, because potentiometric instruments have replaced the human element in the control of temperatures.
These instruments are possible because of the standard cell. It is a "yardstick" for the translation of voltage to temperature and has been Eplab in most cases for a quarter century, because Eplab is "standard as sterling", built for lasting dependability.
THE EPPLEY LABORATORY, INC.
SCIENTIFIC INSTRUMENTS
NEWPORT, RHODE ISLAND, U. S. A.
EPLAB
STANDARD
CELLS
"As Standard as Sterling"
FOR...
POTENTIOMETRIC
INSTRUMENTS

zero. If it is not and the operator is in a hurry, the potentiometer should be standardized for no deflection of the galvanometer by the reversing of the standard cell switch. A thoughtless person may standardize to the zero mark. The user of a recording potentiometer may be inclined to let too much dirt accumulate on the slidewire and presently he may be surprised to note that some of the records appear to be shifted immediately after a good cleaning.

The standard cell used in potentiometers is a two-legged affair designed to generate a constant e.m.f. without having its temperature automatically controlled at a fixed value. The temperature coefficients of the two legs are of opposite sign. So this cell must be placed where the two legs will always be at the same temperature. These temperatures must not exceed the limits from 32° to 140°F. If a cell is damaged by passing these limits or by accidental momentary short-circuit, it will generally recover in a few days to a few weeks. A good cell will last for many years but the e.m.f. generated slowly falls from the standard 1.019 volts. If a new potentiometer is compared with one which is five or six years old, a discrepancy of a few tenths of a percent may be expected. I have known fairly experienced persons to overlook this simple fact.

Resistance Thermometers

Our first precaution is above all things tight connections. The common industrial resistance thermometer has three leads. Two of these leads and their connections must have and remain at equal resistance. This means that they must be kept at the same temperature and not injured. If any permanent change comes about there is no means available of determining whether this change is in the leads or in the thermometer. Only in case four leads are available can the change of resistance be located. Hence we find that it is necessary to retest the industrial forms of resistance thermometers at various temperatures even though it may be made of pure platinum. Of course if it is made of nickel then there is never any sure way of extrapolating test data.

Most resistance thermometers will not withstand much overheating. If the thermometer wire is insulated with organic material a temperature of 150°C. is near the limit. Platinum thermometers with the wire mounted in refractory materials are being employed occasionally for measuring temperatures as high as 1000°C. For such purposes the wire is large in cross section and the resistance very low. In this connection we might remark that resistance thermometers are more sensitive to exposure at high temperatures than thermocouples and once spoiled cannot be restored.

Optical and Radiation Pyrometers

The successful employment of these pyrometers depends to a large extent on familiarity with the laws of radiation obtained either through study or long experience. For example, we find in the Temperature Symposium that Worthing lists eight properties which are designated as emissivities of different sorts. We learn of true temperature, color temperature, brightness, apparent, or blackbody temperature. Apparent temperature to a radiation pyrometer is far different from that obtained with an optical pyrometer sighted at the same object in the open. The optical pyrometer is least likely to mislead a novice especially because things look the same to it as to the eye, while the radiation pyrometer of the thermocouple type sees mostly infrared.

The most successful type of optical pyrometer has been the so-called disappearing filament. In this the observer matches the brightness of an incandescent filament of the pyrometer lamp with that of an optical image of the hot object focused in the plane of the filament. In setting the current through the lamp to the brightness match it is necessary to observe that the center of the visible part of the filament does indeed disappear. If dark fringes appear outlining the two edges of the filament then something is wrong. It may be that the source is too small or that some object is throwing a partial shadow in the line of sight. Possibly there is a large piece of dirt on the front lens. Now if we have a good match with this pyrometer we can't be sure of the temperature this corresponds to unless we know the radiation laws which are applicable. If the incandescent object is not inside a furnace then a great deal of information is required to reach a final conclusion as to what the temperature is. Since this instrument requires an observer to obtain a reading it is designed primarily as a portable instrument and in this form has shown its greatest utility. In fact in experienced hands it serves as a great aid in checking high temperatures even when in some cases these are being indicated by a permanently installed pyrometer.

The radiation pyrometer on the other hand is almost useless as a portable instrument. This is primarily because of the difficulties of judging departures from blackbody conditions and the effects of carbon dioxide and water vapor. Most of the radiation pyrometers used in industry are permanently installed and checked in place either with thermocouples or optical pyrometers. The receiver of heat in these pyrometers has been generally one or more tiny thermocouples. For this reason the temperatures of the walls surrounding the receiving thermocouples have a marked effect on the generated e.m.f. The best results are obtained within limited ranges of temperatures of the receiver, and water jackets are frequently used when the receiver is likely to become too hot. Extension leads are not used but to offset this slight advantage over thermocouples the temperature scale designed for the radiation pyrometer is very far from uniform, being highly compressed at its lower end. This makes it very difficult to apply some types of corrections which might otherwise be readily calculated. Up to the present time the accuracy of the radiation pyrometer has not approached that of the base metal couple up to around 2200°F. nor of the rare metal couple up to about 2800°F. Improvements in design and inventions in this field may better the performance of radiation pyrometers very much. We are in need not only of higher accuracy but of quicker response and of sensitivity to radiation at lower temperatures. At present the lower limit is around 1400°F.

nstruments in he War Effort

Dew-point Indicator Guards Heat Treatment of War Production Components

TO increase war production and safeguard quality of steels treated in controlled atmosphere furnaces, an automatic dew-point indicator developed by Westinghouse metallurgist P. R. Kalisher provides a continuous check on the purity of the hydrogen gas flowing over the metal. Such instrumental control is especially important where the dew

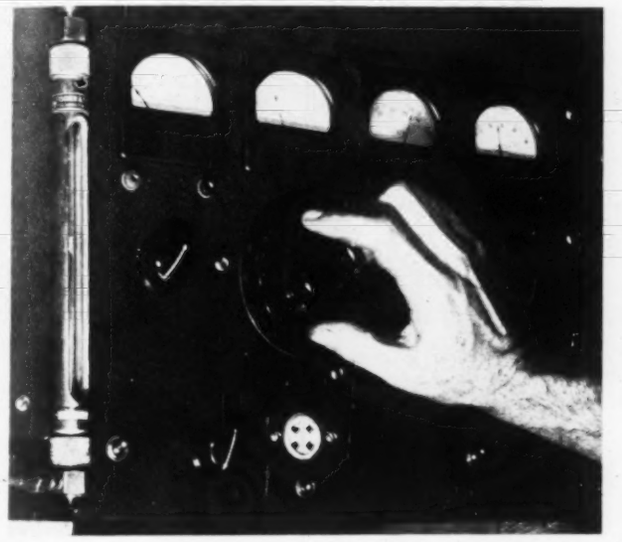


Fig. 1. This detector signals the presence of contaminating moisture or oxygen in the highly purified hydrogen gas commonly used in heat treatment of steel.

point of the treating gas must be maintained in the critical region of —40 C. to —70°C., or for precise furnace conditions such as required for bright annealing, and for chemi-

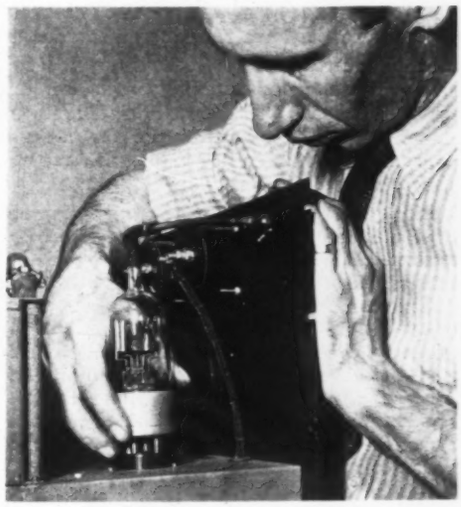
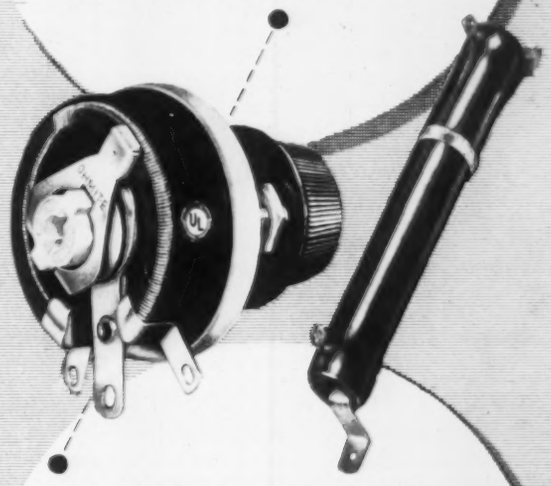


Fig. 2. P. R. Kalisher inserts in its socket a new electron tube he developed for detection of water vapor or oxygen. A continuous sample of the furnace gas (in by hose at top, out by hose at base) passes through this two-element tube.

OHMITE

Resistance Units

for Permanent Performance in Test Apparatus or Control Instruments



The basic design and construction features of Ohmite Rheostats and Resistors have been tested and proved through years of service in critical applications. The extensive range of types and sizes makes them more readily applicable to almost every requirement. And the experience of Ohmite Engineers is especially helpful in selecting the right units for each need. This is well worth remembering when producing instruments for *today*—and *tomorrow*. Many stock types. Units produced to Government specifications or engineered for you.

Send for Catalog and Engineering Manual No. 40

Write on company letterhead for complete 96-page book—gives helpful information and engineering data on the selection and application of Rheostats, Resistors, Chokes and Tap Switches.

OHMITE MANUFACTURING CO.
4887 FLOURNOY ST., CHICAGO

BE RIGHT WITH
OHMITE
Rheostats · Resistors
Tap Switches

Capacitors

A capacitor type to meet every electrical, electronic or radio requirement — that's the basic aim of the Aerovox organization. Two decades of intensive specialization, together with production facilities second to none, stand behind that aim today.

Therefore, when yours is a problem of capacitance, just send it to Aerovox for engineering collaboration, recommendations, quotations. Latest general catalog sent on request.

Heavy duty bakelite case mica capacitor for electronic and radio functions. Typical of the wide range of Aerovox capacitor types in regular production.

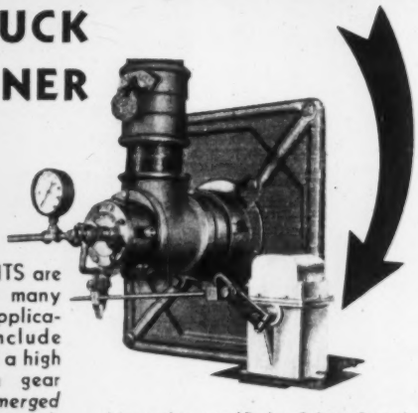
NEW BEDFORD, MASS., U. S. A. Sales Offices in All Principal Cities

AEROVOX CORPORATION

In Canada AEROVOX CANADA LTD. Hamilton, Ont. EXPORT: 100 Varick St., N. Y. Cable: ARLAB

BARBER-COLMAN POWER UNIT

ON A HAUCK OIL BURNER



These POWER UNITS are ideally suited for many industrial control applications. Features include built-in switches and a high torque motor with gear reduction, *oil-submerged* for long life and dependable operation. Control action may be governed by a thermostat or other indicating or recording instrument. The picture shows a POWER UNIT as applied to the air-oil valve on a Hauck industrial type oil burner.

Many other uses of Barber-Colman Controls are suggested in the bulletin "CONTROLS for INDUSTRY" Write for your copy.

MAXIMUM SERVICE Controls by BARBER-COLMAN COMPANY MINIMUM MAINTENANCE

BARBER-COLMAN COMPANY
1202 ROCK ST. • ROCKFORD • ILLINOIS

cal processes, using purified dry hydrogen or similar controlled gases.

To give steel proper characteristics, it often is heated in an atmosphere of highly purified hydrogen that is practically free of moisture and oxygen. Ordinarily, to measure moisture in the gas where dew points are less than 0°C. a cooled and polished metal plate is inserted in the gas stream and the temperature noted when condensation of moisture first occurs. However, below —40°C. this method

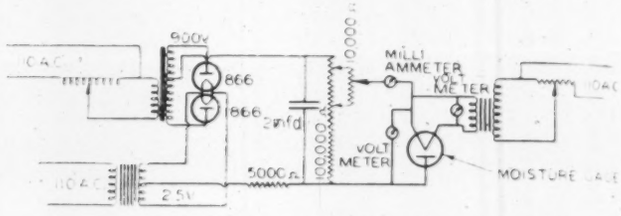


Fig. 3. Simplified schematic of connections. The milliammeter in the plate circuit indicates when moisture or oxygen flows through the detector tube. The unit can be made recording or automatic in control.

becomes largely guess-work, the uncertainty being around 8°C., and even skilled testers disagree on values of the same gas. The new instrumental method insures reliable and accurate determination of moisture and oxygen content in hydrogen (or disassociated ammonia) gas.

In operation, the gas flows through a 2-element tube containing a tungsten filament and plate. Electrons flying from the hot filament to the plate continually bombard the gas. If the gas is pure dry hydrogen all the electrons reach the plate. But any oxygen or water vapor in the gas immediately picks up some of the electrons and form negative ions, thereby reducing the electron current. This change of current in the plate circuit indicates the degree of impurity in the gas. The sensitivity of the instrument is sufficient to detect one-thousandth of humidity in outdoor air on an average summer day: the instrument detects 0.004% water vapor in furnace atmosphere.

Detector Speeds Tube Production

INCREASED production of high-power radio tubes being built at the Westinghouse Lamp Division for the armed forces, has been made possible by the development of a mechanical detector that automatically sorts filaments by spectroscopic analysis, Dr. Harvey C. Rentschler, director of the Division's research laboratories announced.

Known as a thorium detector, the device was invented by Dr. N. C. Beese, laboratory staff physicist. It is credited with cutting hours and guesswork from the necessary testing of wires before they are used in radio tubes.

Government requirements for radio transmitters, detector and receiving tubes necessitate in some cases the use of pure tungsten wire and, in others, thoriated tungsten wire. These filaments when heated produce the necessary electrons for power. If the tubes are made with the wrong kind of wire they burn out in a short period of time.

Introduction of a small percentage of thorium into a tungsten wire increases its ability to emit electrons and gives increased efficiency to certain types of tubes. The different tubes require the tungsten or thoriated tungsten filaments for maximum efficiency, but they are not interchangeable.

Until recently, thoriated tungsten filament wire could only be detected by chemical or mechanical analysis. In the former process, wire was dipped in several acid solutions and the residue examined for thorium content. The other method consisted of heating the wire and if it snapped very easily, it was considered to have thorium in it.

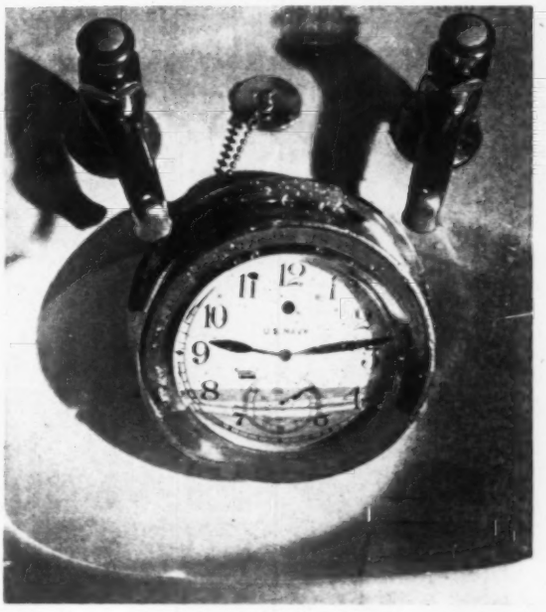
The thorium detector, in conjunction with a spectroscope, detects the presence of any appreciable amount of thorium in tungsten wire. The new thorium detection method, which eliminates guesswork and speeds up the testing of wire, consists of introducing a sample of pure tungsten or thoriated

tun[illegible]en wire into an electric carbon arc. As it burns completely, two lines appear in the spectrum if the wire is pure tungsten; four appear if it contains any thorium.

A portion of every coil of tungsten wire now passes the watchful "eye" of the instrument before being cut and made into small filaments. This sorting process separates the thoriated tungsten wire from pure tungsten wire.

Severe Test of a Water-tight Case

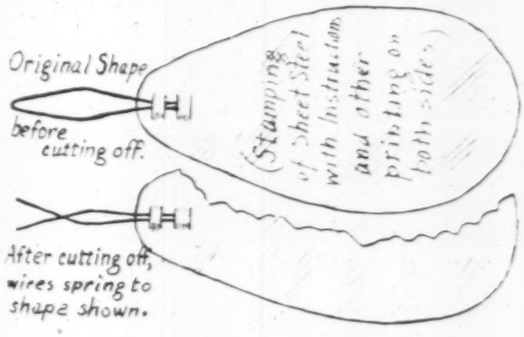
WATER-TIGHT after 112 days in Davy Jones' locker. That's the story of this clock case which was aboard the ill-fated Squalus when this U. S. submarine sank near the Isle of Shoals off Portsmouth, New Hampshire, in May



1939. When the Squalus was raised 112 days later, this clock "was the only mechanical device in working order," [according to a news release okayed by the Navy Department]. The Plexiglas crystal on the clock was made completely air- and water-tight by an ingenious heat fusing technique known as the "Perm-O-Seal Method," developed by Dutcher Bros. of New York.

SHOP KINK—PEN CLEANER

IN five- and ten-cent stores, needle threaders are sold which can easily be made into effective pen cleaners. Such is the kink described in a letter to *Instruments* by Herman W. Bocher, 4501 Richmond St., Philadelphia. Mr.


Original Shape
before cutting off.
After cutting off, wires spring to shape shown.
Stamping of Sheet Steel with Instructions and other printing on both sides.

Bocher sent us a sample, which we have sketched (the illustration is actual size). Mr. Bocher advises that the ends of the spring-steel wire be cut off square. He does not mention what kind of pen he uses it on, but we believe that it will serve equally well on recorder pens of several kinds, on ruling pens, compass pens, etc.

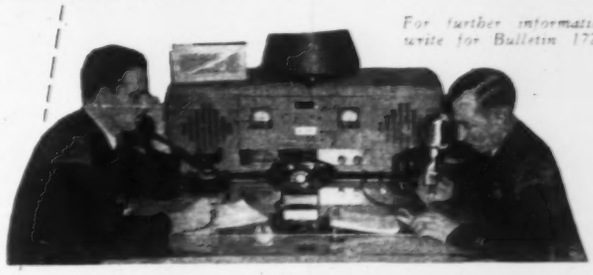
The Shure Super-Cardioid Microphone

Reproduction of the voice that commands attention! The Shure Super-Cardioid Microphone combines special engineering for more efficient voice response, with the Cardioid pickup pattern . . . sensitive at the front—dead at the rear. This diagram of the photo below shows how the Super-Cardioid rejects background noise and other unwanted sounds. It "spotlights" the pickup of sound on the operator. Contrast this with

The Conventional Microphone

This Microphone picks up sound from every direction as you can see in the diagram at the left. Background noise, reverberation, room reflection interfere with the important call. The Shure Super-Cardioid is the exact answer for Airport and Police Broadcast, and for Industrial sound applications.

For further information write for Bulletin 172W



SHURE BROTHERS

Designers and Manufacturers of Microphones and Acoustic Devices

225 West Huron St.
Chicago, Illinois